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ON THE IMPORTANCE OF THE CULTIVATION OF SCIENCE.[1]

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GENTLEMEN: I beg leave to tender you my sincere thanks for the honor you have conferred upon me by inviting me to preside at the farewell banquet to Professor Tyndall. I need scarcely say that it would give me great pleasure to be with you on that interesting occasion, although I would prefer not to occupy the place your partiality would assign to me, since I fear I should not be able, from want of experience, to do justice to so conspicuous a position.

I regret, however, to have to inform you that my official duties in Washington, at this season of the year, are such as to render it improper for me to be absent for even a single day; and, although I deeply sympathize with you in the objects of the banquet, I am obliged very reluctantly to forego the pleasure and profit of accepting your kind invitation.

The objects of this banquet, as I understand them, are, first, to do honor to our illustrious visitor, who has generously devoted so much time and labor to gratify his friends and the public in this country with a course of lectures; and, second, to advocate the claims of abstract science to higher appreciation and more liberal support. In regard to these topics I ask permission to indulge in a few remarks which may not be deemed inappropriate to the occasion. Dr. Tyndall is eminently worthy of all the attention he has received from the people and press of this country, and all the expressions of kindness and regard we can now bestow upon him. As Professor of Physics in the Royal Institution of Great Britain, he is the worthy successor of a

[1] Letter to the Committee of Arrangements of the Farewell Banquet to Professor Tyndall, at Delmonico's, New York, February 4, 1873.

series of the most remarkable men of the present century. He is not only a distinguished laborer in the line of original research, but also one of the best living expounders of scientific principles. His books are everywhere read in this country with avidity, and have done more to give precise and definite knowledge of the principles of the sciences of which they treat than any other series of works ever published. Indeed, it is only a master in science who is capable of preparing elementary scientific works. With a modesty—or, perhaps, self-respect—which constitutes a distinguishing trait of the man of true science, Professor Tyndall omitted to mention the fact that many of the phenomena which he presented in his lectures were his own discoveries. In the proposition which he has announced of giving the proceeds of his lectures to advance the cause of abstract science in this country, he has evinced another characteristic of the higher type of the scientist—namely, a paramount regard for his mission and a generous sympathy with humanity, as expressed in an aphorism of the founder of the Smithsonian Institution, that "the man of science is of no country; the world is his country, and mankind his countrymen."

In an age and country which boasts of its intelligence it might seem superfluous to say a word in regard to the importance of the cultivation of science, or, in other words, of a knowledge of the laws of the phenomena of the universe of which we form a part, yet it is lamentably the case that few comparatively, especially among statesmen and politicians, and even among those devoted to literature and the fine arts, properly appreciate the influence of abstract science on the present condition of the civilization of the world. Living in the present, enjoying its innumerable comforts and facilities of life, they do not realize the conditions of the past, or, if they imperfectly realize them, the changes are attributed to fortuitous circumstances really exercising a subordinate influence, or to apparent proximate causes such as the immediate practical application of science to art.

It is only of late years that the investigations of the tendencies and changes of the human family have been systematically studied under the general denomination of anthropology, and its subdivisions of ethnology and archæology. From these studies we may infer that man is a being capable of indefinite moral and intellectual development; not that he is a progressive being from the result of a law of necessary development, but, as it were, providentially so under the influence of certain essential conditions, among which are, first, freedom of intercourse of different peoples, and the ready interchange of thought; second, a prevailing religion which shall enjoin purity, love, justice, and truth; and, third, an ever-increasing knowledge of the laws, or principles, of the changes of the phenomena of Nature which constitute abstract science. That man is not necessarily a progressive being is shown by the fact that large portions of the inhabitants of the world are still in a condition of barbarism, from which they show

no indications of emerging, and cannot probably do so except by influences from without.

Whatever opinion may be adopted as to the origin of man, it cannot be denied that we have descended from a race of ancestors but little elevated above the brute—from naked savages, the denizens of caves, feeding upon wild fruits, devouring shell-fish, or struggling for mere existence with the larger quadrupeds of the times, gradually emerging from this state by the invention of weapons of flint and bone, through long geological periods, into a pastoral condition; thence, again, into a higher state of mental development, which culminated in the civilization of Greece and Rome, in which the true in sentiment, and the beautiful in art, were developed in an astonishing degree. This progress was mainly due to the migratory character of the races which contributed to the condition we have mentioned. Tribes which remain entirely isolated may utilize the suggestions and facilities of life which are afforded them by their localities, and when these are exhausted become permanently stationary, but tribes impelled by want of subsistence, or the desire of conquest to migrate to other localities, as is stated to have been the case with the Aryan race in their migration from the East to the West, gather up the separate civilizations as they advance, and hence, by accretion or intercourse with others, rise to a higher plane. But this mode of advance is limited, and could make no further progress than that exhibited in the brilliant though unsymmetrical civilization of Greece and of Rome. This civilization, though it challenges our admiration and marks an important era in the history of the human race, was deficient in two of the essential elements of further progress, namely—first, in the prevailing influence of the higher and holier morality of Christianity; and, secondly, in that scientific knowledge of the laws of Nature which enables man to control its operations and to employ its energies to effect his purposes in ameliorating the condition of the earth. Without these elements of progress the Romans could not advance beyond a limited degree, and finally fell a prey to their barbarian conquerors.

Being confined in my remarks on this occasion to the discussion of the influence of physical science, I can only advert to the ameliorating effect produced by Christianity in its restraining influence on the semi-barbarism which followed the fall of the Roman Empire, and its aid in preserving the learning of the past through the darkness of the middle ages, and must leave to our theological brethren the full discussion of this part of our theme.

It is a fundamental principle of political economy that the physical state of man can only be ameliorated by means of labor, or, in other words, by the transformation of matter from a crude to an artificial condition. But this cannot be effected, except by expending what is called *power* or energy. In ancient times, almost the ex-

clusive source of this energy was muscular force, derived from compulsory human labor; and all the monuments and objects that have been left to us, as marks of ancient civilization, are the results of organized systems of slavery. The rock-sculptures of Elephanta, the Pyramids of Egypt, and the temples of Greece, were all the result of the labor of slaves, directed by the minds of freemen. It is said that a hundred thousand slaves were employed at one time in the construction of the Pyramids of Egypt; one hundred and twenty thousand were engaged in hewing the obelisks of Thebes, and an equal number in digging the ancient canal which joined the Nile and the Red Sea. These slaves were treated as beasts of burden, or as mere machines, of which Athens, in her palmy days, had four hundred thousand, with but *twenty thousand* freemen.

Now, we owe the abolition of this condition of humanity, in the higher civilized nations of the world at the present day, to the study of the laws of the operations of Nature. By a knowledge of these laws the energies of the elements of Nature are substituted for human labor, and by this substitution mankind is not only relieved from brute-labor, but also given control of energies which enable him to produce effects which could only result from the muscular power of beings of a superior order. It may be shown by a simple calculation that about fifteen tons of anthracite coal burned in the furnace of one of our best steam-engines exerts an energy equal to that of an able-bodied slave, working ten hours a day for thirty years of his active life. It is this substitution of the energies of Nature for the power of human muscle that, as we have said, has abolished slavery and elevated humanity to a higher plane than was ever dreamed of by the wisest sages of ancient times. To illustrate this, a few examples will suffice. As one of these, we may refer to the progress of the arts of locomotion, and the means which science has afforded for the instantaneous interchange of thought between men in the most distant parts of the earth; as another, to the production of clothing fabrics, in which a single individual, directing the energies of an engine of one-man power, is capable of doing three thousand times the work of an ordinary weaver. As a third example, we may point to the art of printing by means of the steam-press, in which a single man will make more copies in a given time of a composition, than a million of ancient transcribers could do. Science is every day creating new arts, and modifying and improving the processes of old ones. We are skeptical as regards the value of *lost arts*. It is true there are arts which have fallen into disuse, and others which depend upon the skill and patience of the individual, but none which rests on any lost secret of Nature which science cannot restore.

The results we have mentioned are frequently attributed by superficial observation to immediate practical invention of persons having little or no knowledge of abstract science. But, in regard to this, it

must be recollected that our whole civilization is pervaded by a knowledge of facts primarily derived from scientific investigation. Such inventions as those we have alluded to are not produced in a barbarous country, or even in those of a comparative high civilization without science.

If we desire an illustration of the condition of civilization based upon empirical art, upon facts accidentally discovered, or invention without science, we have merely to turn to China and Japan. These countries have long since utilized all the facts and empirical processes the result of accident or simple invention, and have, consequently, remained stationary for thousands of years, and must remain so continually, unless they borrow a knowledge of science from abroad.

It is not, however, merely the material wants of man that are gratified by the results of science; it administers also to his highest intellectual development. Placed in a universe of constant change, on an isolated globe, surrounded by distant celestial objects on all sides, subjected to influences of various kinds, it is a sublime occupation to measure the earth and weigh the planets, to predict their changes, and even to discover the materials of which they are composed; to investigate the causes of the tempest and volcano, to bring the lightning from the clouds, to submit it to experiment by which it shall reveal its character, and to estimate the size and weight of those invisible atoms which constitute the *universe of things*. It is the pursuit, above all, which impresses us with the capacity of man for intellectual and moral progress, and awakens the human intellect to aspirations for a higher condition of humanity, and gives a pleasurable consciousness to those who successfully pursue it, of contributing, in however small a degree it may be, to such a desirable consummation. The effect of such pursuits on the mind of the individual himself cannot be otherwise than salutary. While it exalts the understanding, it exercises the imagination, and awakens and constantly cherishes a love of truth for its own sake. The man imbued with the proper spirit of science does not seek for immediate pecuniary reward from the practical applications of his discoveries, but derives sufficient gratification from his pursuit and the consciousness of enlarging the bounds of human contemplation, and the magnitude of human power, and leaves to others to gather the golden fruit he may strew along his pathway. This fact is strikingly illustrated in the generous devotion by our illustrious visitor of the proceeds of his labors in this country to the advance of science.

In the foregoing remarks it is not our wish to disparage any other pursuit, or to diminish the love of ancient literature, but, on the contrary, we would cherish whatever tends to develop the human mind. We would carefully preserve the knowledge of the past, and transmit it to posterity, enlarged by the achievements of the present. We hold that every age of the world has had its mission, and has left its

impress upon all the ages that have followed. The lessons taught by the Greeks have not been forgotten. The examples of beauty and the vestiges of truth they have bequeathed to us, still exist to ameliorate the condition and improve the moral character of a thousand times greater number of individuals than was effected by them in the palmy days of Hellenic development. But we should not unduly exalt the past, or claim for it a superiority over the present. There never was a time in which the realms of actual thought were so extended as at present, nor when so many individuals were occupied in the contemplation of abstract truths.

Such being the results proceeding from science as we have stated, it appears strange that so little encouragement is given to its prosecution, and that it should not be more liberally fostered by governments and wealthy individuals. In a new country like this, where a whole continent is to be subdued, and there is so great a demand for the practical application of science to art, it is not surprising that the great principles which underlie these applications while they can be borrowed from Europe should not at first receive much attention; but, since our country has become so much advanced in wealth and in intelligence, this state of things should no longer exist, and it is therefore proper on an occasion like this to call public attention to the importance and wants of abstract science.

In this country, science is almost exclusively prosecuted by those engaged in the laborious and exhaustive employment of imparting instruction. Science among us brings comparatively little emolument, and is accompanied with but little honor. High talents are therefore driven into other pursuits more remunerative and more favored with popular applause. Those who from a love of truth would pursue it for its own sake are so overworked with the drudgery of elementary teaching, and so poorly supplied with the implements of investigation, that it is not surprising that science has made comparatively *little* advance among us, but that, under existing conditions, it should have made *so much*. What is especially wanted at present is an improvement in our higher institutions of learning, and on this point permit me to dwell a few moments.

Three things are essential to a well-constituted college or university: 1. An unencumbered, free endowment, which shall liberally provide for the support of the faculty, and defray all the expenses of the operations of the establishment; 2. A faculty consisting of men of profound learning and powers of original thought and fluent expression; and—3. A full supply of all the objects and implements of instruction and research. I say a "free endowment," in contradistinction to one invested in buildings intended for external display more than for internal use, as is unhappily too often the case in this country.

The faculty should be men of intrinsic worth, chosen, not on account of influential connections, social position, denominational pre-

dilections, nor for any vague popular reputation, but especially in the line of science, from having given evidence of their power in the way of original research. A man of this class must be possessed of enthusiasm which in a measure he can scarcely fail to impart to his pupils. The latter, again, by a reflex action, will stimulate the teacher to new efforts. Furthermore, the reputation of the teacher is shared by his pupils; and to have sat under the instruction of a Cuvier, a Laplace, a Faraday, or a Herschel, is no small recommendation. It is to the men of which the faculties of the German universities are composed, that those establishments owe their reputation, and *they* are the attraction which draws pupils from every part of the world to these centres of high intelligence. But men of this character "are *not made*," but, like poets, "*born*." Profound learning is not sufficient; however versed a man may be in the knowledge of others, he is not of the first order unless he be endowed with the peculiar mental powers which enable him to originate new truths. When such men are found—and they exist in every community in a certain, perhaps small ratio, they should be consecrated to the advancement and diffusion of knowledge. They should be secured by our colleges and universities, and all the facilities given them for original investigation. They should be relieved from the drudgery of drilling in the elementary branches, and be assisted by tutors in the general instruction, being themselves only called upon to give a limited number of lectures on the general principles of the branch of knowledge under their care.

Again, no college or university is properly equipped that is not furnished with a complete series of the objects and implements of instruction and research. In regard to instruction, the impressions made through the eye are the most definite and indelible, and may serve as nuclei around which by association to group facts and suggestions the most varied.

In science, to present the actual phenomena of Nature and reproduce them before the eye of the pupil, instead of giving him a mere description of them, is as different in effect, as *travelling* in a foreign country is from merely obtaining a knowledge of it through the writings of others.

In reference to original research, as well as to higher instruction in science, besides apparatus of illustration, instruments of *precision* are required, without which the power of the investigator, however gifted, must be greatly limited.

In what I have said in regard to science in this country, I do not wish to be understood as undervaluing what has already been done. Indeed, in view of the small encouragement which has been given and the limited facilities which have been afforded, the contributions which have been made from this country, especially in the line of astronomy, geology, geodesy, topography, and natural history, are numerous and important. At the commencement of the General Government, in the

union of the several States, a large demand was made for a certain degree of practical astronomical knowledge in determining the boundaries of the different States, and Territories; and, later, the establishment of the Coast Survey, and an Engineering Bureau, has tended to keep up an interest in investigations relative to these subjects. The wide extent of our national domain, and the gigantic scale on which its geological formations are presented, have served as the basis of valuable contributions to geology, mineralogy, botany, and zoology. The contributions that have been made within the last forty years to meteorology, especially in the simultaneous observations over the large extent of our country, and the subsequent comparison of results, have materially assisted in developing the laws of storms, and have almost advanced meteorology to the character of an exact science. While there have been no especial facilities for prosecuting chemistry or physics, yet American researches in these lines have not been unfruitful of results worthy of a place in the history of science.

But whatever may be said as regards the value of the contributions of this country to the scientific knowledge of the day, it must be admitted that there is a great popular craving among us for a knowledge of the results of scientific investigation, and that in no other part of the world could Prof. Tyndall have been more highly appreciated or more enthusiastically welcomed.

It must be to him a source of high gratification to have his sympathies so widely extended, and his kindly feelings so warmly reciprocated. There is a spirit of improvement awakened in this country in regard to scientific investigation which I doubt not will be stimulated into more active exercise by the visit of our illustrious friend, which will induce men who, by the exercise of peculiar talents, have accumulated wealth, to endow institutions for the special cultivation of scientific investigation, and to set apart with liberal support as the priests or interpreters of Nature, those who by special mental endowment are capable of benefiting their fellow-men by the discovery of new principles.

We trust the time is not far distant when the grand philosophical vision of the father of modern science, which has waited so long for its fulfilment, will be realized, "by the union and coöperation of all in building up and perfecting that House of Solomon" (as Bacon quaintly termed it), "the end of which is the knowledge of causes and of the secret motions of things, and the enlarging of the bounds of human empire to the effecting of all things possible."

While we have endeavored to show that abstract science is entitled to high appreciation and liberal support, we do not claim for it the power of solving questions belonging to other realms of thought. What we would claim for it, however, in addition to liberal appreciation and support, is, that it may be untrammelled in its investigations so long as they are conducted with the single intention of the dis-

covery of truth, and according to the strict methods of inductive philosophy. Much harm has been done by the antagonism which has sometimes arisen between the expounders of science on the one hand, and those of theology on the other, and we would deprecate the tendency which exhibits itself in certain minds to foster feelings antagonistic to the researches into the phenomena of Nature, for fear they should disprove the interpretations of Holy Writ made long before the revelations of physical science, which might serve for a better exegesis of what has been revealed; and also the tendency in other minds to transcend the known, and to pronounce dogmatically as to the possibility of modes of existence on which physical research has not, and we think never can throw, positive light. We freely admit that the laws which relate to dead matter apply equally well to all living organic bodies, but we are constrained at the same time to believe in the existence of a mysterious something lying beyond this, working through the laws of Nature as it were by immediate intelligence and by prearrangement, producing results marked in the future by evidences of design.

The analogy between crystallization and organization has never impressed me as being well founded. If we allow the existence of atoms endowed with the simple force of attraction in right lines, these must, of mathematical necessity, group themselves in geometrical figures—three forming an equilateral plane triangle, four a solid tetrahedron, and so on. But this is very different from the case of atoms spontaneously grouping themselves in the form of eyes, ears, and limbs, instruments of optics, of acoustics, and of locomotion, or organs of thought and emotion.

In all cases of transformation of organic matter, a definite amount of potential energy is expended; for example, in the incubation of an egg, a considerable portion of the material within the shell runs down from an organic condition in combining with the oxygen of the atmosphere, into carbonic acid and water, and in this evolves the power or energy necessary to build up the future animal out of the remaining material.

The work accomplished in this operation is at the expense of the energy evolved by the chemical action; that is, this energy instead of evolving heat or other mechanical motions, when suffered to expend itself without direction, is, in this case, employed in accomplishing results of intellectual character, or, in other words, precisely such as are produced when the energy of coal is employed by an intelligent being in manufacturing articles intended for useful purposes. Again, when we pass from the phenomena of life to those of mental and moral emotions, we enter a region of still more absolute mystery, in which our light becomes darkness, and we are obliged to bow in profound humiliation, acknowledging that the highest flights of science can only reach the threshold of the temple of faith.

Gentlemen, I have restricted my remarks to a few divisions of the general subject of the importance of the cultivation of science, and leave it to others to develop other points of the same subject in their bearing on the welfare of man.

THE NEBULAR HYPOTHESIS.

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THE speculative views of Lambert and Kant led them to the adoption of a Nebular Hypothesis, and to the idea of a perpetual development in the regions of space. Sir William Herschel, after long hesitation, was ultimately led, by the surer path of observation and cautious induction, to the adoption of similar views, in relation to the existence of a self-luminous substance of a highly-attenuated nature, distributed through the celestial realms. At a later period, in 1811, he communicated to the Royal Society an exposition of his famous hypothesis of the transformation of nebulæ into stars.

Sir William Herschel made no attempt to extend his hypothesis to a cosmogony of our solar system. If, therefore, the "Nebular Hypothesis" is restricted to the theory which professes to explain the genesis of our solar system, it is only analogically related to the loftier speculations of Sir William Herschel, in regard to the processes of star-formation going on in the stellar realms. In this restricted sense, the "Nebular Hypothesis" is due to Laplace. This illustrious mathematician, with a modesty and diffidence befitting a true philosopher, endeavored to lay rational foundations for a cosmogony of the solar system. This sublime speculation has been egregiously misunderstood and misrepresented alike in itself and in its tendencies.

The lecturer proposed to disconnect Laplace's Nebular Hypothesis from the question of the general diffusion of cosmical vapor in the celestial regions. Indeed, the origin of Laplace's hypothesis did not lie in Herschel's speculations in relation to the transformation of nebulæ into stars and clusters of stars. In contemplating our solar system, he discerned numerous harmonies and adjustments, which were not accounted for by the law of gravitation, which induced him to infer that all its members were of one family—of a common origin. The Nebular Hypothesis was framed to explain and coördinate these facts, and, if possible, to refer them to established mechanical principles. Under this view, the lecturer considered the Nebular Hypothesis in two aspects—viz.: As a pure hypothesis, framed to explain the arrangements of the solar system; and as a physical reality, indicating the actual process by which the phenomena were evolved or produced.

Notwithstanding the number of orbs of which the solar system is composed, and the consequent almost infinite variety of their possible dispositions, the following coincidences—wholly independent of the law of gravitation—are found to obtain: 1. The sun rotates on his axis from west to east. 2. All the planets (now 104 in number) revolve about the sun from west to east. 3. All the planets (as far as known rotate on their axes from west to east. 4. All the satellites (excepting those of Uranus and Neptune) revolve about their primaries from west to east. 5. All the satellites (as far as known) rotate on their axes in the same direction in which their primaries turn on their axes. 6. All the planets (with the exception of a few minute asteroids) revolve about the sun, nearly in the plane of the solar equator. 7. All the satellites (as far as known) revolve about their primaries nearly in the planes of the equator of their respective planets. 8. All the planets (with the exception of a few asteroids) have orbits of small eccentricity. 9. All the satellites have, in like manner, orbits of small eccentricity.

These nine independent coincidences in the arrangements of more than 127 separate bodies, cannot be supposed to be fortuitous—they naturally suggest the existence of some grand and comprehensive law, pervading the whole solar system. That they are not consequences of the law of gravitation, is evident from the fact that the comets transgress every one of these laws which could be applicable to them. According to the laws of probability, the chances against the concurrence of so many unconnected phenomena are almost infinite. Laplace estimated that the chances were four millions of millions to one, that these were not arbitrary acciendtal phenomena. Since his time, facts of a similar bearing have largely accumulated, and the chances against their fortuitous concurrence are now almost beyond the power of numbers to express. "The coördination of these divers and unconnected phenomena—the grouping them into one coherent and harmonious scheme—the referring them to one common cause and origin, and thereby imparting to this fair work of the Eternal the semblance of a Unity worthy of a Divine Idea"—these were the sublime and lofty aims of the famous "Nebular Hypothesis" of Laplace. He imagined "that this consummate fabric—this gorgeous planetary scheme—like the blossom, had a bud—and deeper yet, that it had a mysterious germ, within which rested the necessities of its present glorious unfolding! . . . . He sought, by penetrating the deep recesses of the past, to reveal the mystery of its development, and conceived the bold thought of portraying the *modus operandi* of the genesis of our Solar System."

In its original form, the Nebular Hypothesis required three assumptions, viz.: 1. An agglomerated nebulous mass; 2. That this mass be rotating about its centre of gravity; and 3. That it be incandescent from excessive heat. The successors of Laplace have endeavored to simplify the hypothesis, by showing that rotation of the nebulous mass,

and perhaps also its incandescence, may be simple consequences of the processes of aggregation.

The lecturer proceeded to show that if we suppose the great nebulous mass to have been a continuous gas or fluid, symmetrical in form, and either homogeneous or heterogeneous in structure, provided the component strata were homogeneous in themselves—"the fundamental principles of mechanics assure us that the process of cooling and condensation by contraction, would not generate a motion of rotation." Nay, more; he thought it was very difficult to conceive the mechanical possibility of a continuous gaseous or liquid mass of any form—whether homogeneous or otherwise—acquiring a motion of rotation by the internal motions of its several parts. The mass being isolated, and out of the sphere of external forces—all of its parts being in intercommunication through fluid continuity—how can we reconcile a generation of rotation in the whole mass, with the fundamental principles of the equality of action and reaction? Any force, that begins and ends in a body—whose parts are in continuous material connection—cannot impart motion to the whole mass—whatever relative movements might be communicated to portions of it.

The lecturer was disposed to look for the origin of the primitive rotation of the nebulous mass in the discontinuous structure of the primordial nebulous matter. Adopting Sir John Herschel's idea, that the nebulous condition indicates not the gaseous, but the cloudy form of matter, we must look upon nebulous masses as consisting of discrete portions of matter—of various density and bulk—aggregated into special forms, under the influence of mutual attraction. By the gradual subsidence and condensation of these discrete particles by the effect of gravity, a central aggregation or nucleus would be formed—the germ of our sun. Let us hasten to see what light this view throws upon the physical cause of the rotation of the primitive solar nebula. It is obvious that a crowd of aggregating bodies, animated by independent and partially-opposing impulses, must produce collision, destruction of velocity, and a subsidence toward the centre of attraction. It is also evident that those impulses which conspire or remain outstanding after such conflicts, must ultimately give rise to circulation or rotation of a permanent character about some axis. It will be observed that the causes imparting motion to the central mass are, in this view, entirely exterior to it. For the subsiding and conflicting bodies, being discrete and independent of each other, act like the impinging of a comet, or any cosmical mass, on the central nucleus. Under this aspect, the Nebular Hypothesis becomes identical with Sir John Herschel's "Theory of Sidereal Aggregation;" the only difference consisting in the magnitudes of the aggregating bodies.

Instead of supposing that the primitive or chaotic condition of matter was intensely hot, is it not more rational to suppose that it was originally deficient in heat or cold, and that the high temperature was

subsequently developed during the processes which brought about its organization? According to the preceding view of the structure and constitution of a nebulous mass, the idea of the chaotic matter being maintained in a diffused and attenuated condition through the agency of heat, is by no means necessary. Indeed, the assumption that the primitive matter of the universe existed in a diffused gaseous condition, through the agency of excessive heat, is itself, *prima facie*, improbable. If it were absolutely universal, what became of the heat, and how did the cooling and condensation commence? Even if we suppose that the chaotic matter existed in enormous detached masses, what an inconceivable amount of heat must have been created, merely to be dissipated throughout the infinitudes of space! Such a view ill accords with our conceptions of the economy of the Creator's operations.

According to the views previously announced, the original concentration of the nebulous matter about a central nucleus was not the result of cooling and contraction, but of a gradual process of aggregation of discrete bodies under the action of mutually-attractive forces. Now, in the collisions and frictions necessarily incident to this process of aggregation, we have an indefinite supply of heat. The establishment of the "Dynamical Theory of Heat," on the sure basis of experiment and observation, assures us that when motion is checked or arrested, it is transformed into heat. Hence, we see that the collisions and destruction of velocity, incident to the process of aggregation, while imparting a motion of rotation to the nebulous mass, at the same time evolved heat, more or less, throughout its structure—and especially toward the nucleus, where the bodies, whose velocities had been checked, were gradually subsiding. The larger portion of the "dynamical energy" of the crowd of bodies aggregating toward the nucleus, was thus transformed into heat—a smaller portion remaining in the motion of rotation of the solar nebula. This view makes the heat- and light-producing process continuous and gradual, and the true gaseous and fused conditions of the nebula, subsequent states, induced by the evolution of intense heat.

We thus reach a lofty point of view. Given diffused or chaotic matter, and mutual attraction, and the whole machinery of the Nebular Hypothesis is set in action! The "star-dust," or "world-stuff" begins to aggregate—heat is evolved—rotation is imparted—and all the apparatus required for the formation of suns, planets, and satellites, is established! Assuming that the processes of aggregation and heat-evolution had so far progressed that the rotating spheroid consisted of a more or less continuous mass of liquid or gas, extending far beyond the orbit of Neptune, and we are furnished with all the conditions assumed by Laplace.

It is unnecessary to follow the lecturer in his exposition of Laplace's reasoning, by which it was shown, upon mechanical principles, that, as the rotating spheroid slowly contracted and condensed by the grav-

itation of its parts toward the centre, and the process of cooling at its surface, the rotation must necessarily be accelerated, and consequently the centrifugal force augmented, particularly at its equatorial parts. In fact, this could not be done without the use of illustrative diagrams. Suffice it to state, that the final result would be, the development of a system of planets, revolving in a common direction around a vast central solar mass, with subordinate systems of satellites circulating in a like direction around their primaries. These are precisely the arrangements which are found to exist in our solar system.

Assuming that the primitive solar nebula rotated on its axis, as the sun does, from west to east, the following consequences were deduced from the theory, viz.: 1. All the planets should move around the sun from west to east. 2. All the planets should rotate on their axes from west to east. 3. All the satellites should rotate on their axes from west to east. 4. All the planets should revolve about the sun in orbits nearly coincident with the plane of the solar equator. 5. All the satellites should revolve about their primaries nearly in the planes of the equators of their respective planets. 6. All the planets should revolve in orbits of small eccentricity. 7. All the satellites should revolve in orbits of small eccentricity. 8. The central mass—the sun—should rotate on his axis in less time than any of the planets revolve about him in their orbits. 9. The primary planets should revolve on their axes in less time than any of their satellites revolve around them; and 10. The central mass, left after the process of genesis was completed, should contain a much larger quantity of matter than the sum of the masses separated. All of these arrangements (with a few unimportant deviations), were shown to exist in the solar system. Recapitulating these coincidences, we obtain the following significant results, viz.:

8	planets	satisfy	3	of	them,	making	24 coincidences.
6	"	"	1	"	"	6	"
3	"	"	1	"	"	3	"
5	"	"	1	"	"	5	"
96	asteroids	"	3	"	"	288	"
13	satellites	"	3	"	"	39	"
22	"	"	1	"	"	22	"
1	sun	"	3	"	"	3	"

Total, 390 coincidences.

"We thus see that there are no less than 390 independent phenomena—of which the law of gravitation gives no account—which are simple consequences of the Nebular Hypothesis. In the aggregate, they imply a very large number of facts—complex—diverse—unconnected with each other—having no mutual dependence—all accounted for by a simple supposition, and the aid of the known laws of matter and motion." It can hardly be denied that, regarded as a pure hy-

pothesis, framed to account for a certain set of facts, its remarkable success in explaining them invests it with a high degree of probability.

It was admitted that the theory had encountered some apparent difficulties—some want of coincidences—the most serious one being the retrograde direction of revolution of the satellites of Uranus. It was shown that this anomaly might be reconciled with the Nebular Hypothesis during the first stages of planet-formation.

But, it has been asked, may not these coincident phenomena be explained by other means than the Nebular Hypothesis? May they not be arrangements instituted by the Creator, for the purpose of giving perpetuity to our solar system, and making the planets suitable habitations for organized beings? And do we not transgress the legitimate domain of scientific research in attempting their explanation?

In reply to this, it was urged that such a view implies a total misconception of the doctrine of final causes. In such inquiries, "we are not to assume that we know the object of the Creator's design, and put this assumed purpose in the place of a physical cause." In these provinces of speculation, the principle of final causes is no longer the basis and guide, but the sequel and result of our physical reasonings. . . . As physical science advances, final causes do not disappear. The principle of design changes its mode of application, but loses none of its force; it is merely transferred from the region of facts to that of laws." We do not consider the sun as less intended to warm and vivify the tribes of plants and animals, because we find evidences that the earth and other planets were developed in the vast periods of past ages, from a common nebulous mass! We are rather, by the discovery of so general a law, led into a scene of wider design—of deeper contrivance—of more comprehensive adjustments. "The object of such views is not to lead to physical truth, but to connect such truth—obtained by its proper processes and methods—with our views of God—the Master of the universe."

But even admitting this application of the principle of final causes, it was shown that the conditions of stability of the solar system, and its adaptability to living beings, are totally insufficient to account for all the observed coincidences. There are many other phenomena in the arrangements of our system, which have no relations to these ends or purposes. It was shown that there are no less than seven sets of phenomena, of which the principle of final causes affords, as far as we can see, no explanation.

The Nebular Hypothesis not only accounts for and coördinates all the arrangements of the solar system, but the conditions of stability and adaptability to living beings are simple consequences of its mode of genesis! Does not the cheering doctrine of final causes—of design and purpose—become strengthened and invigorated by leading us to a view so comprehensive? "How simple the means—how multiform the

effects—how far-reaching and grand the design!" How deeply they impress us with the wisdom, power, and glory of the Creator and Governor of the universe!

We now come to consider the physical reality of the fundamental assumption of the Nebular Hypothesis. Have nebulous masses a real existence in the universe? Is the Star-dust—the World-stuff—a physical reality, or a mere figment of the brain of the theorist? If the actual existence of self-luminous nebulous matter—the chaotic elements of future worlds and suns—can be established—the fundamental assumption of Laplace loses the character of a pure hypothesis: his conception becomes a physical theory, which, in proportion as it is verified by phenomena, approaches the domain of fact—a *vera causa*.

It was shown that the highly-diffused and attenuated matter constituting comets, as well as that constituting the zodiacal light—while affording some suggestive analogies to nebulous masses—do not furnish examples in all respects identical with the supposed nebula of Laplace. We are, therefore, compelled to fall back on Sir William Herschel's opinion, that there are numerous nebulæ which really consist—not of clusters of stars, but of a diffused, self-luminous, vaporiform matter. Such bodies are, beyond all question, self-luminous, but the question is, Are they clusters of stars or true nebulæ? In other terms, are they optically or physically nebulous?

For a long time, this question was keenly discussed, and opinions fluctuated in regard to the tenability of the fundamental assumption of the nebular hypothesis. It is well known that, since 1846, the tendency of telescopic observations, as revealed by the magnificent instruments of Lord Rosse, and corroborated by the splendid achromatic of Harvard University, has been to break down Sir William Herschel's distinction between stellar clusters and true nebulæ. After the sword-handle of Orion was broken into glittering fragments, shining with separate and distinct lustre, Sir John Herschel himself was disposed to abandon the opinion of his illustrious father.

But the development of a new and wonderful branch of physical science has recently furnished the most satisfactory proofs of the reality of such bodies. We allude to the application of Spectrum Analysis to the study of the celestial bodies. The well-matured speculations of Sir William Herschel, and the mathematical theory of Laplace, have been vindicated from the doubt under which they have been laboring, and the early nebulous condition of the cosmical matter has been demonstrated. The accomplished Sir John Herschel has been permitted to witness the complete verification of the previsions of his illustrious father; to see the link connecting the past with the present in the cosmogony of the universe—which seemed to have been almost ruptured by the extension of telescopic vision—restored and strengthened by this new branch of physical investigation.

Until recently the light from the heavenly bodies, even when collected by the largest telescopes, conveyed to us but very meagre information. With regard to the moon, sun, and some of the planets, in addition to their form and size, we have been able, by this means, to obtain some slight knowledge of their physical structure. But, with reference to the myriads of stars, clusters, and nebulæ, which people the depths of space, the telescope reveals little more than variety in color, brightness, and shape. (In relation to the nebulæ, this was illustrated by diagrams contrasting the appearance presented by the same objects when viewed in the telescopes of Sir John Herschel and of Lord Rosse.)

The discovery of "Spectrum Analysis"—the optical Analysis of Light—enables us to interpret symbols and indications hidden within the light itself. Wherever the tiny waves of light—the swift messengers of the celestial realms—can penetrate, they bear with them intelligence of their origin! "Bodies, so remote that astronomers fail to give us an idea of their distance, are brought, as it were, into our grasp, and are analyzed with certainty! We recognize in them the same elements which compose the soil we tread—the water we drink—the air we breathe!"

Before proceeding to explain the manner in which this new method of investigation decides the question of the existence of true nebulous masses in the regions of space, it is necessary to recall certain well-known and long-established principles in optical science. In 1675, the immortal Newton demonstrated the composite nature of solar light. When a ray of sunlight is made to pass through a glass prism, it is refracted and spread out into a fan-like band, so as to exhibit exquisite gradations of color, from red at one end to violet at the other. This constitutes the Prismatic or Solar Spectrum. In 1802, Wollaston discovered that this spectrum is not continuous, but is interrupted by a number of dark lines. In 1815, Fraunhofer, by great improvements in the optical arrangements employed, rediscovered these lines—ascertained that their relative distances from each other were fixed for sunlight—and succeeded in mapping no less than fifty of them as belonging to the solar spectrum. Since that time, the number of these lines has been increased to thousands. The sagacious Fraunhofer traced these same dark fixed lines in reflected as well as in direct solar light: he found them quite unaltered in position, in the spectrum of moonlight and Venus-light. He, likewise, discovered, that the spectra of the fixed stars contained dark lines differing from those seen in the solar spectrum. He thence drew the important conclusion that these lines have their origin in the luminary. Fraunhofer thus opened the inquiry; but the explanation and import of these lines were reserved for a subsequent epoch.

Modern investigations have established the existence of three orders of spectra depending upon the source of the light: 1. A continu-

ous spectrum—uninterrupted by lines—is produced, when the light emanating from solid and liquid incandescent bodies is passed through a prism. 2. A spectrum interrupted by bright lines is produced when the light emanates from flames or ignited vapors and gases. 3. A spectrum interrupted by dark lines is produced, when light emanating from a source giving a continuous spectrum, is passed through gaseous or vaporous matter giving spectra of the second order.

Now, it has been found that, when various elements are volatilized in the flame of a lamp, the light gives a spectrum interrupted by bright lines—whose character and position are different for different elements. It has also been discovered that the dark lines of spectra of the third order correspond precisely in position with the bright lines in spectra of the second order: they thus indicate the existence of elements which are volatilized in the ignited vapors or gases. The coincidence of position of these bright and dark lines was first observed and described by Foucault, of Paris, in 1849; but their real significance was first indicated in 1859, by Kirchhoff, of Heidelberg. These delicate lines carry across the immeasurable abysses of the celestial spaces evidences of their origin!

The numerous lines of the spectrum are separated from one another—the fan of light is opened out—its entire pattern is brought distinctly under view—and all of its minute details are revealed—by transmitting the light through a succession of prisms: this constitutes the Spectroscope. (This was illustrated by a diagram.)

By means of the spectroscope, no less than fourteen terrestrial elements have been identified as existing in the sun's atmosphere. Mr. Willian Huggins and Prof. W. A. Miller, by ingenious modifications of this instrument, have been able to extend spectrum analysis to more than sixty of the brighter fixed stars. Like our sun, they give spectra with dark lines; thus indicating that the stars (as the sun) must have intensely heated solid or liquid nuclei, surrounded by ignited gaseous atmospheres.

Encouraged by his success with the fixed stars, Mr. William Huggins applied the potent method of spectrum analysis to the examination of the nebulæ. He was rewarded by a most important discovery in relation to the physical constitution of these wonderful objects. On the 29th of August, 1864, he applied his spectroscope to a planetary nebula in Draco. He was astonished to find that there was no appearance of a band of colored light, such as a star would give; but, in place of this, there were three isolated bright lines on a dark ground—a true gaseous or vaporous spectrum. In other words, the object was not a cluster of stars, but a true nebula. Mr. Huggins was not slow in following up this line of investigation. During the two years succeeding his first observation, he examined the spectra of more than sixty nebulæ and clusters. Of this number, about twenty gave spectra with bright lines; that is, were gaseous bodies. The remaining forty

gave stellar spectra. Among the true nebulæ may be mentioned, the Annular Nebula in Lyra; the Dumb-bell Nebula; and the great Nebula in the Sword-handle of Orion—concerning the nature of which there has been so much discussion.

These spectrum investigations afford tangible and unmistakable evidence that there are in space, masses of ignited gaseous or vaporous matter of prodigious extent, shining by their own light, and resembling the vast nebula which the Nebular Hypothesis declares to have been the original condition of our solar system. The nebulous matter, assumed as the basis of the hypothesis, is no figment of the theorist!

What great results have been achieved by the power of means apparently the most trivial! Immense objects, seemingly unattainable, have been grasped by the smallest conceivable handle! A little instrument, which is scarcely any thing more than a small triangular piece of glass, solves questions which hundreds of thousands of dollars expended in telescopes, and years of observation, could not have settled! Penetrating into the illimitable depths of space, it reveals to us something of the physical and chemical constitution of stellar clusters and nebulæ, so remote, that the light which the spectroscope analyzes, must have left them thousands, perhaps millions, of years ago!

The lecturer concluded with the following reflections, which are given without abridgment:

In contemplating the vastness of the sidereal universe, every person, in every age and country, must recognize as irresistibly natural, the train of thought expressed by the Hebrew Psalmist, when he exclaims: "When I consider thy heavens, the work of thy fingers, the moon and the stars, which thou hast ordained; what is man, that thou art mindful of him? and the son of man, that thou visitest him?" (Psalm viii. 3, 4.)

How incalculably has this withering sense of insignificance been augmented by modern telescopic excursions into the remote recesses of the stellar universe! When, by measurements, in which the evidence of the method advances *pari passu* with the precision of the results, the volume of the earth is reduced to less than one-millionth part of the volume of the sun; when the sun himself, transported to the region of the stars, takes up a very modest place among the thousand of millions of those bodies revealed to us by the telescope; when the ninety-five millions of miles which separate the earth from the sun, by reason of their comparative smallness, have become a base totally insufficient for ascertaining the dimensions of the visible universe; when even the swiftness of light barely suffices for the common valuations of science; when, in short, by a chain of irresistible proofs, certain stars and nebulæ have retired to distances that light could not traverse in less than millions of years—we feel as if annihilated by the immensity of the scale of the universe! In assigning to man, and to the planet he inhabits, so small—so insignificant—a position in the

material world, science seems only to have made progress to humiliate and to humble us!

Let us accept the lesson of humiliation, with a proper sense of reverence! But, while humbling ourselves in the presence of the overwhelming vastness of God's creation, let us not degrade ourselves: let us not imagine that so insignificant—so ephemeral a being—groping about on so minute a speck in the universe—is totally unworthy of a Creator's care; or entertain the debasing idea that there is no life—no hope—beyond this transient state of existence! Such a view is not the legitimate result of the proper sense of humility which true science demands. She teaches us that grand humility which annihilates self, and places the soul as a child-like learner in the face of God's universe! Like the sacred Shepherd, with unsandalled feet, we advance with reverential awe upon the holy ground, and receive assurances that our minute sphere is benignly noticed by the eye of Omniscience; that, amid the surrounding grandeur, man is not overlooked!

But let us not forget, that there is another aspect under which such contemplations may be viewed, which is calculated to exalt man in the scale of creation. When we reflect on the extreme feebleness of the natural means by the help of which so many great problems have been attacked and solved: if we ask ourselves how such results have been attained; how have we been enabled to assure ourselves of this stupendous scale of creation—of the resplendent glories of the illimitable realms of space—the feeble being resumes all his wonted dignity! By the side of such wonderful achievements of the mind, what signifies the weakness and fragility of our body; what signifies the dimensions of the planet—our residence—the grain of sand on which it has happened to us to appear for a few moments!

From this point of view, man is exalted to his true dignity, through his spiritual and intellectual nature. A mind capable of accomplishing such results must indeed be an emanation from Deity! We must have within us some feeble spark of Divinity! Yes, there is a life and a hope beyond and above this transient existence!

> "'Tis the Divinity that stirs within us,
> 'Tis Heaven itself that points out an hereafter,
> And intimates Eternity to man."

Yes, the lofty aspirations of humanity are not delusions; they are realities. They link us with a purer order of existence, which makes us heirs of immortality. We repose under a confident and unwavering assurance that, in God's own time, these earth-mists will be dispersed, and the dim twilight of conjecture will yield to the glorious, unclouded noonday of knowledge.—*The California Teacher—Abstract of a Lecture.*

RIVER AND LAKE TERRACES.

TRAVELLERS along the river-valleys of New England, and in other sections of our Northern States, will observe that the banks in many places rise by a series of terraces, which at a distance resemble the steps of an amphitheatre. Carved with singular uniformity upon the slopes, they are everywhere a striking and beautiful feature of these most picturesque and beautiful landscapes. In the valleys of the Connecticut, Merrimac, St. Lawrence, Kennebec, Hudson, and innumerable other streams, these levels have been utilized as sites for villages, country-seats, forest, and cultivation.

Northampton, Brattleboro, and Springfield, are built on terraces; and part of the charming village of North Conway, at the gate of the White Mountains, stands upon a similar level. Dartmouth College is upon an elevated terrace.

Terraces occur on both sides of the Niagara River, and on the east side four levels are described, the highest being 38 feet above the top of the American Fall. They occur also on the Hudson Highlands at Cornwall 180 feet, and at Cozzens 130 feet above tide-level. The Catskill Mountains are fringed with terraces almost to their summits; and on the east side of the Hudson, at Albany, eight distinct levels are passed on the line of the Boston and Albany Railway before reaching the summit station.

On Hoosac Mountain is a terrace 1,813 feet above the level of the sea, and near it an ancient beach 200 feet higher. They occur at Quebec, 560 feet; at Montreal, 400 feet; and, on the Genesee River, 1,410 feet above the ocean-level.

But terraces abound on lake-margins with the same distinctness as on the banks of rivers. Prof. Agassiz counted fifteen on the shore of Lake Superior, and the writer counted six, beautifully defined, at Portage Lake. Visitors at Watkins Glen may notice terraces sculptured on the amphitheatre of hills at the head of Seneca Lake, whose geological history is contemporary with that of the great gorge, the object of their visit. In Northern Utah lake-terraces are found, according to Hayden, nearly a mile above the ocean, and on islands in Barrow's Straits they occur at 1,000 feet elevation.

On some of the great Western prairies terraces extend like vast coast-lines bounding the plain.

Nor are they confined to North America. They have been noticed on the slopes of the Ural and Altaï Mountains, around the Dead Sea, on the banks of the river Jordan, on the mountain-sides in the Great Sahara, and on the banks of the Nile above the first cataract.

The ocean, too, has its terraces. Darwin observed that, around Patagonia, the ocean had eaten deep into the rocky coast "a series of

step-like plains." Roads are carried up the Cordillera on elevated terraces to a height of 9,000 feet.

These formations, so widely distributed and so uniform in their aspects, have an important geological significance. They are evidently among the latest results of the dynamic agents which have modified, and are still modifying, the surface of the globe. Those along the banks of rivers have been formed during the erosion of the valleys. Their history, therefore, begins with the development of the present

FIG. 1.

TERRACES IN LIMESTONE CLIFFS, WORN BY WAVES.

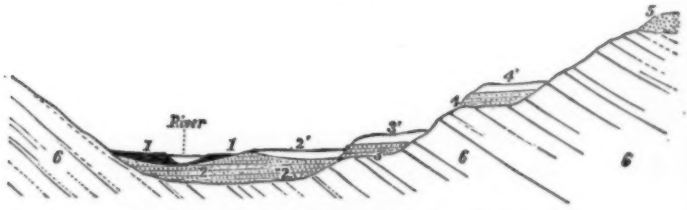
river-systems, and comprises what is known in geology as the "Terrace Epoch." They are most abundant and perfect in the drift latitudes—that is, where the continental floors are deeply covered by the waste and *débris* of the Glacial Period, which closely preceded that of the Terraces. If we examine the valley of a gently-flowing river, we may study all the processes by which it was formed, and step-like terraces distributed along its banks.

There is the channel along which the stream is flowing. By the side of it, at intervals, are verdure-covered meadows and deposits of shingle and sand, overflowed during periods of rain and freshet. These constitute what may be termed the river-flats or flood-plains. Something is added to it during each overflow. Meanwhile, the river-channel is deepening by the wearing action of the current and transportation of the materials of its bed. At length the waters are discharged along the channel, and no longer overflow the flood-plain, which becomes at once a terrace, the last formed and newest of the series, the oldest of which may be more than a thousand feet up the bank. Fig. 2 shows a section of a river-valley with terraces on one side only, a circumstance which frequently arises from sinuosities of the stream.

The newly-made terrace now really forms the bank or banks of the

stream, and is itself slowly worn away and distributed elsewhere by the abrasion of annual freshets. Portions of it may thus disappear, but other portions remain.

FIG. 9.



TERRACED RIVER-VALLEY.—1, 2', 3', 4', and 5, are Terraces.

It is obvious that terrace-formations occur in greatest perfection where the stream is not very rapid. Where it flows as a torrent, a flood-plain or delta may form only at its mouth. Sometimes, however, a swift stream is checked by the accumulations of *débris* or by rocky gorges, forming lake-like basins around which terrace-formations occur with great uniformity and beauty. The Connecticut River is 1,589 feet higher at its source than at its mouth; and, according to Prof. Hitchcock's excellent report on the Surface Geology of New England, twenty-two such basins, or levels, occur in its descent.

It is evident, as we have observed, that the highest terrace of a series is the one first formed and the oldest, but, when formed, was equally, with the last one, the flats, or flood-plain, of the river; whence it follows that the river was then much higher as regards the general level of the land than now. Its present deep valley was not excavated, but it by no means follows that the river was any higher as regards the level of the sea. A change of level has, indeed, taken place, but it has been of the land, not of the ocean. No truth in geology is better established than this perpetual oscillation of the crust of the globe, and from the unchanging ocean-level is measured the extent of the movement.

The process by which a river-valley is excavated, and terraces formed upon its banks, is directly connected with this elevation of the land. Indeed, it could occur only during a period of elevation, and may have commenced with the emergence of the land above the waters, for then would begin the flowing of streams and their concentration into larger ones, forming at last our magnificent system of rivers. During a period of subsidence, however, the rivers disappear, as their valleys are filled, and the land is overflowed by the invading ocean. Nor is proof wanting of submergence of a very large portion of this continent, especially that which is north of the fortieth parallel, directly following the Glacial and preceding the Terrace Epoch; and nowhere is that fact more apparent than in New England.

The occurrence of ancient beaches above the terraces on Hoosac Mountain, and among the White and Green Mountains 2,200 and 2,600 feet above the ocean, proves its former presence and the movement of its currents and waves.

At that period the site of the present rivers was the bottom of an ocean. It was during the progress of that period of continental depression and submergence that the glacial drift was modified and redistributed, forming enormous deposits, filling old basins and river-valleys, so that when the land emerged from the waters it was comparatively level, a few mountain-peaks rising above the plain.

It is at this point, as we have seen, that the present river-system with its terraced valleys begins, and the phenomena may occur in the following order:

1. Elevated beaches, indicating ancient sea-shores.
2. The highest river-terraces.
3. Continuous excavation of river-valleys, and formation of flats, or flood-plains.
4. Elevation of those plains above the overflow of the river, forming terraces.

The process of formation we have already described; nor does it appear that any dynamic agent was then in operation which is not in operation now. The work has been continuous.

The superposition of terraces early suggested the idea that their origin was due to a succession of sudden elevations of the land rather than to a continuous movement, and such, indeed, may have been the case in some instances. But their usual want of uniformity through long distances and of correspondence on opposite sides of the valley induces the conclusion that their immediate distribution is controlled by local circumstances, while the general cause has been a continuous and gradual elevation of the land, and the equally continuous action of running water. Currents of rivers are thrown from side to side by ice-borne bowlders and accumulations of *débris*, and pebbles will become so adjusted in the river's bed as to resist erosion, as shown in Fig. 3.

FIG. 3.

SHOWING THE POSITION ASSUMED BY PEBBLES IN THE BED OF A STREAM.

This is one of the causes of the sinuosities of rivers. The water, as Sir Charles Lyell observes, is thus frequently forced to cut new channels, by which means new terrace flats may be formed by redistribution of materials.

The transporting power of running water depends on its velocity. Hopkins, cited by Prof. Dana, says that its force varies as the sixth

power of its velocity—that is, doubling the rate, increases the force sixty-four times. "If a stream running 10 miles an hour would just move a block of five tons' weight, one of 20 miles would move one of 320 tons." When shallow streams are suddenly swollen to torrents, bowlders of considerable size are borne along with heavy roar—are broken by collision, and ground to pebbles and sand. Hence we find that heavy rock-masses are abundant near the sources of a river, finer materials along its valley, fine sand and silt at its mouth. The material thus comminuted is prepared for distribution over the terrace-flats and plains along the river's bed.

The following table is from Mather's "Report on the Geology of the State of New York:"

A stream having a velocity of—

3	inches	per second	wears away fine tough clay
6	"	"	removes fine sand.
12	"	"	removes gravel.
24	"	"	removes pebbles one inch in diameter.
36	"	"	moves angular fragments having a diameter of two or three inches.

The latter velocity is, however, very moderate, being little over two miles an hour. In estimating the transporting power of rivers, we must consider the important fact that rocks lose nearly one-third of their weight in water.

The formation of terraces on the borders of lakes has, equally with those along the banks of rivers, arisen from elevation of the land. By this means the drainage of Lake Superior became possible, and its terraces represent former levels of its waters. Nor less interesting is the fact that the great plains of Northern Africa, including the Sahara and the valley of Egypt, were emerging from the sea while the Nile was excavating its valley and carving into terraces the sands of the Nubian Desert more than 200 feet above the present bed of the river. The wave-eaten shores of Patagonia have been elevated above the ocean, and its terrace-plains, equally with those of lake and river valleys, constitute an epoch of geological history, and record the most profound of the earth's secular changes.

APPLIED SANITARY SCIENCE.

By J. R. BLACK, M. D.

IN the intellectual field there are two distinct classes of laborers: the discoverers, or those who pursue science for its own sake; and the appliers, or those who seek to make the knowledge it confers useful, and so turn it into a direct source of profit to themselves, and, in a general way, to the public. The genius each displays differs from the

other: the one being delighted in finding out and making his way into the unknown, while the pleasure of the other consists in seizing results, and putting them into shape, so that they may be servants to our will. The history of electricity strikingly displays these distinct aptitudes and pursuits. Volta, Franklin, Arago, and Faraday, were leading discoverers of the properties and laws of electricity. They cared far less about the every-day use which might be made of the newly-discovered force, than of gaining a complete insight into its nature, and of making it the means of unlocking other secrets of the natural world. On the other hand, Morse and Wheatstone thought only of electricity as a means to an end, or of reaching, through some ingenious contrivance, the means of rendering human communication, at distant points, practically instantaneous.

A knowledge of the leading facts upon which sanitary science is founded is, at least, as old as history itself. It antedates the time of Moses; many of the rules of hygiene having been taught by the Egyptian priests. But more especially within the past two centuries has the knowledge of the ways in which disease is produced, and may be avoided, been corrected and extended. It is within this period that the first attempt was made in Europe to establish quarantines. The sum of the precautions taken in London during the middle ages to guard against the ravages of the plague, was the isolation of infected houses, and putting a red cross on house-doors, on which were inscribed the words, "Lord, have mercy on us."

The physician of to-day, who has devoted half as much thought to the prevention of disease as to its cure, firmly believes in human ability to avoid nearly all the ills to which flesh is now subject. Given a good constitution, and the conditions of health or sickness are almost wholly in our own power. He believes this, and on precisely the same grounds that the geologist believes that fossils are not what was once universally believed, the primary result of the action of a plastic or creative force in Nature. A like belief exists in the popular mind in reference to health and longevity, though in a less positive form. Families known to be of good constitution, and of ancestry noted for their length of days, are not expected to be sickly and short-lived. When any member of such a family does become a permanent invalid, and likely soon to die, it is a familiar expression, and notoriously true, that he or she has abused the endowment inherited.

Passing over the evidence which has convinced those the most competent to judge in reference to the prevalence of disease—the physicians—to their conclusion, that if all possessed good constitutions, and lived as they ought to live, in accordance with hygienic law, there would be no disease, or next to none, and death would not come upon the human family through a morbid process, but by the only truly natural mode of dying—old age; the question arises, How do men come by good constitutions? Through a course of life by progenitors for

several generations, precisely the opposite of that course which makes a bad constitution out of a good one. Any one who has attained to life's meridian will be able to recall examples of good constitutions converted into bad ones. Children, parents, and grandparents, in some families, often stand thus in regard to constitutions:

Grandparents scarcely know what sickness is, and die of old age;

Parents: constitutions much impaired, often sick, and die in middle life;

Children: constitutions very defective, and are rarely well a week at a time.

This is the downward career of life-force, which almost every one has witnessed; the upward career being the result of a precisely opposite course. In place of abusing the constitution there is the most careful husbanding of its resources, and avoidance of all the causes which will impair its vigor. The purity and strength which such a course of conduct begets is transmitted; the child starts in the world on a higher plane of life-force than the parents did; and if the offspring continue to carry out the reformation thus inaugurated, the result will be to bring back the pristine vigor, health, and longevity, which an opposite course had destroyed.

Such are some of the elementary truths forced upon the attention by every-day experience on the great problem of obliterating sickness and death by disease. As has been stated, these elements of sanitary science have long been known. But in spite of this, and of the facts that this science has of late been purged of many errors, and its bearings and capabilities greatly extended, disease, deformity, decrepitude, and untimely death, prevail almost as much as ever. Where, then, is the weak point in sanitary science? Is it in the imperfection of the science itself, or is it in its applications? Reverting to the history of electrical discovery and its applications, will give us aid in solving the question. We have seen that the discovery of the great truths about the electrical force employed one class of scientific experts, and applying these truths employed another class of scientific experts. Now, we have had in abundance the discoverers of the truths of sanitary law, but we have not, nor can we have, as in electricity, experts who can carry out for the advantage of all, the benefits which hygienic law is capable of conferring. There cannot be, in sanitary matters, ingenious contrivances, by which a certain class of men can manipulate health and long life into their fellow-beings. Its truths, if applied at all, must be mainly applied by those who desire its benefits; or every one must apply the science for himself or herself, else nearly all the knowledge there may be on the subject will be as if it were not. Here we have plainly before the mind the great and peculiarly weak point, so far as the practical benefits are concerned, which this science may be capable of conferring. To make it profitable and useful, or, in other words, to make it an applied science in a community, that

community must be made, one and all, experts in its knowledge and in its applications.

This last consideration should lead educators to bestow a preëminent importance to a thorough course of instruction in hygiene. It is all well enough for the young to learn more or less about the philosophy of electricity and magnetism, but, as the great majority of them in after-life will make very little, if any, use of this knowledge, its importance practically dwindles to very small proportions. Wholly different is it in the case of sanitary science. Every one can make of it in after-life most important, and ultimately momentous uses, not occasionally, but during every day and hour of life. And, if thus applied, its benefits would transcend those of any other branch of knowledge; it would tend to make man a master of himself, of his pains, deformities, and mortal afflictions.

We have said that the applications of sanitary science must be made *mainly* by the individual members of society. This is true of the kind of air breathed, of the food and drinks partaken, of the clothing worn, etc., etc. But where human beings are clustered together, their sanitary relations are so intimate that it becomes absolutely necessary for the general good to define and regulate some sanitary matters by law, which each member of a community cannot, as an individual, regulate for himself. It is not possible, for example, for one in a densely-populated place, to enforce regulations for a supply of wholesome water, for carrying off to a safe distance all the refuse and noxious matters of a great city, or to protect himself from the presence of persons suffering from infectious diseases. It is here plainly the duty of the State to exercise supervision for the general good, and to protect all, as far as may be possible, against evils which a few persons may fight against in vain. There is absolutely no difference, except in the matter of will, between the danger of allowing a person who has a mania for putting poison into the drinking-water of a city, by which many perish, and one who puts the poison of small-pox into the air of a city by which hundreds are slain. In the former case, even if it were the work of an idiot, or of an irresponsible person, and if he were known to be travelling over the country, liable at any moment to enter a city, would not the officers of the law be considered exceedingly derelict in duty if they did not carefully guard against his entrance? And, if such a class of persons were in a city infecting others with their mania, would not all applaud the law and the efforts of its officers in securely confining them where they could do no harm, taking from them the means by which they injured and destroyed the lives of others? This is precisely what ought to be done with every one in a densely-populated place laboring under an infectious or contagious disease. When out of a city, such dangerously-affected persons should be watchfully excluded until cured of their disorder; and, when in, a cordon should be placed around them, so that the com-

munity would be in no danger; all the while carefully stamping out with disinfectants the means or the germs by which disease and death are carried from house to house.

It should for these reasons be a maxim with the law-making power to protect the health and lives of the people, whenever individual effort is powerless or insufficient; and, moreover, to provide that pure air, wholesome drink and food, should be made possible to every inhabitant of a town or city. If the refuse matter and *excreta* of a city are not promptly and carefully removed; if the streets are not of the proper width, and regularly cleansed; if houses are allowed to be so constructed that effective ventilation is impossible; if the water-supply is insufficient, or tainted with organic matter; and if persons are allowed free entrance, suffering with dangerous infectious diseases, and no well-directed efforts are made to destroy the noxious matters thus introduced, misery, disease, and a fearful rate of mortality, will be the normal results. The few who make diligent efforts to apply the rules of sanity are powerless in removing the obvious causes of the prevailing misery and death-gloom, and, like Lot, for safety, must flee the city.

With a private and public hygiene thoroughly understood and effectively maintained, there is not an intelligent physician in our land who would not acknowledge that the result would be to diminish the prevalence of disease at least one-half, and to send the average expectation of life, at a bound, up a decade of years.

Taking into consideration the fact that it is within the power of sanitary regulations to prevent yellow fever, as was shown in New Orleans while under occupancy during the late war by the Union forces for more than two years, where over 100,000 unacclimated soldiers were stationed, or passed through the city, without a single case of the disease originating there; that it is possible to stamp out the germs of Asiatic cholera and small-pox, and say, "Thus far shalt thou go, and no farther;" and taking into consideration that the average duration of life has been extended during the past two centuries from nineteen to thirty-one years, by a slow appreciation and imperfect application of sanitary law alone; taking these, and many other facts of a like character, into consideration, it does not seem too much to say that it is within the power of any one with a moderately good constitution to say whether he will choose to cut short his days and die the violent death of disease, or whether he will extend the powers of his body to their normal limits, and so die from the effects of old age, or from the gradual wearing out of the most imperfect organ of his body.

Pecuniarily, the results of properly-applied sanitary law would be immensely successful; the cent of prevention would be more than worth the dollar of cure. It is estimated that from a half to three-fourths of the inhabitants of our principal cities are sick some time during each year of ordinary salubrity. The loss of time which there-

by results, the expense of nurses and medicines, and, above all, the permanent impairment of the health and shortening of life which thereby ensue, are fruitful sources of the worst misery and the deepest indigence. These conditions become, in turn, the great nurseries for crime, and for filling our poor-houses, asylums, hospitals, and penitentiaries. During the years when an epidemic scourges a city, its business becomes for the time paralyzed, and a serious check is put upon its growth and prosperity.

But, more than these, sickness throughout the United States supports in comparative affluence, at least, 75,000 persons with their families. The physicians and dentists amount in round numbers, according to the last census, to 55,000, and the druggists, pharmaceutists, and patent-medicine venders, to about 20,000 more. Add to all this the munificent charities maintained for those who are directly or indirectly sufferers from the effects of preventable diseases, such as the deaf, the blind, the insane, and the imbecile asylums, and the aggregate outlay for avoidable evils assumes enormous proportions.

In reference to health and sickness, the civilization of the nineteenth century presents this remarkable spectacle: millions of dollars annually spent, indescribable torments and anguish endured from an evil which it is possible, but never seriously attempted, to remove. The dark shadow of a barbarous ignorance yet overspreads the popular mind, that sickness is somehow produced by evil causes, whose dreadful attacks we may patiently watch and fight with drugs, but whose ultimate destruction belongs alone to the gods. The danger of an attack by some dreadful disease is yet looked upon with a feeling akin to superstition, not with the calm confidence of security which a thorough knowledge of cause and effect alone can bestow. Slowly, oh, how slowly! does the human mind awaken to the truth that in this, as in every thing else pertaining to the natural world, nothing happens by chance, nothing of arbitrary will, but all is subject to immutable law. This truth once fully recognized and acted upon, man would exhibit the same power and success in subduing in his own body the one great obstacle to his weal, as he has shown in subduing the obstacles to his weal in the external world, and he will then become the most healthy instead of the most sickly of beings.

The proper means for accelerating such a hygienic reformation consists in making it possible for all to become experts in the application of the science of life. In effecting this, the State has the two great requisites in its own hands: first, to educate and train the youth of our country so that they may realize the importance, and be enabled to apply, sanitary science for themselves; and, second, to make it possible, wherever there is a dense population, for every one to carry the laws of hygiene into effect, and to protect the people against those who have disregarded its injunctions, and so have become focii for multiplying and disseminating the seeds of infectious diseases.

BARBARISM IN ENGLISH EDUCATION.

By E. E. WHITE.

PROF. W. H. YOUNG, formerly of Athens, Ohio, now United States consul at Carlsruhe for Baden and Alsace-Lorraine, has sent us a very interesting epitome of the recent odd discussion in the English papers, chiefly in the *Times*, of the oddest feature of English public schools. The discussion contains so much that is English, unique, and suggestive, that we regret that we are obliged to condense the epitome to bring it within our space. We have made as few changes as possible, but, that Prof. Young may not be responsible for the sketch in its present shape, we have given it an editorial position.

The term public school is commonly applied in England to such schools as Eton, Rugby, Harrow, Winchester, etc., which correspond with an American endowed boys' academy on the dormitory plan. Each school comprises several "houses" and about six classes called "forms," and is under the immediate management and instruction of ten to twenty assistant "masters" presided over by a "head-master," and subject to a corporate board of control. In all of these schools Monitorial Discipline has prevailed more or less for centuries, with this striking feature, that all the boys in the lower "forms" are subject, not only in ordinary school discipline, but for personal service of whatever kind, as cleaning rooms, brushing clothes, bringing wood and water, all kinds of errand-running, etc., to the "sixth form," commonly limited in number from fifteen to thirty of the best of the most advanced boys, who are clothed with authority, and are held responsible for keeping order at all times, in study, in dormitory, on the playground, etc. This service by the lower form is called "fagging," and is enforced with rigor just as other discipline—the ashen rod being in constant use. Of the "sixth-form" boys a designated few, called in the school "preposters" or "prefects" and in sports "leaders" or "captains," are of still higher authority—a sort of court of appeal, and the real disciplinarians of the school. A boy when abused may appeal to these, next to an "assistant master" (teacher), and finally to the "head-master" or principal; but these appeals are, in fact, almost never made. The "code of honor" is against it, and an English boy will bear almost any amount of cuffing, kicking, and beating, before he will appeal. Of course such a system is liable to the grossest abuse.

Further, in these, as in other English schools, physical prowess in sports ranks little, if any, behind mental excellence. The "prefects" in the schools are "captains" in the field-sports, and feel themselves responsible, rather to the English sport-loving public, than to the school authorities, for the athletic proficiency of their several divisions. All of these sports involve a large amount of slang that must be famil-

iarly understood to secure successful coöperation in such games as cricket, football, etc.

The case of discipline which gave rise to the recent discussion, is this: A prefect at Winchester sent for a "house" (the boys of a particular building) to examine them in their "notions," i. e., perhaps, in their general school-boy proficiency in matters out of study. One boy refused to come, on the ground that, being a senior fifth-form boy, he could not be fagged. The prefects held a meeting, decided his conduct rebellious, and that he must be "tunded"—that is, should be whipped with ground-ash rods. The boy appealed to the head-master, who told him he must submit to the "tunding." The number of "cuts" which a prefect may give, is theoretically limited to twelve; in this case thirty were given.

A Mr. Maude reports the matter to the London *Times* as a specimen of "licensed tyranny," worse than any "bullying" (by which the English understand a large boy imposing on a small one), a gross relic of past centuries, disgracing English public schools, and demanding the interference of English public opinion for its suppression. He says a "tunding" is far worse than any master's flogging; the ash rod is as large as the finger, three feet long, seasoned until tough as whalebone, and that not less than four must have been broken over the boy's back, leaving it in a condition horrible to be thought upon. The head-master, when appealed to afterward, condemned the decision of the prefects, pronounced the punishment excessive, but only required of the "tunding" prefect a private apology, instead of expelling him and punishing his associates. Mr. Maude had been five years at Winchester, and remembered scores of these "tundings," but never one so gross as that described.

Next a Mr. Fischer, in the *Times*, applauds Mr. Maude's "admirable letter," condemning without stint the "cruel and cowardly iniquity" long prevailing at Winchester; could give cases where the punishment had been more barbarous than garroter-flogging at Newgate; for the latter was inflicted by law, within legal limits, and in the presence of responsible officials, while the former was in violation of all law, and in the absence of all authority or protection to shield the lad from the anger of his school-fellows; boys should be punished by the masters or in their presence, and the latter should not be allowed to delegate such authority to other boys; the system is brutalizing to punisher and punished—the one hardened by indulgence in cruelty, the other only maliciously biding his turn to inflict on others the harm he has received, and both made brutal and cowardly men.

A Mr. Lechmere deplores the public censure likely to fall upon his revered preceptors of a former generation as a result of Mr. Maude's painful letter. No such torture as "tunding" was known at this peaceful time; was four years a junior at Winchester, and never knew

a severer punishment than a moderate knuckle rap on the head, inflicted by prefects deemed "bullies."

An "Old Wykehamist" (Winchester was founded by Mr. Wykeham), who recently spent six years at Winchester, admits the main facts of the "deplorable case" reported by Mr. Maude, but protests against his conclusions as to the general condition of things at the school. The power of the prefects is limited by the right of appeal and their own sense of a grave responsibility, and "tundings are rarely and reluctantly inflicted, and only for grave moral offences and grave breaches of discipline." The system is perhaps wrong, because liable to abuse, but the "brutality," which Mr. Maude had so justly stigmatized, was very exceptional, as was proved by its general condemnation by even the friends of the system.

These letters call out the "victim," who speaks for himself, avowedly of his own will and motion, "in defence of my school." He thinks that a "Winchester tunding" is not, as alleged by Mr. Maude, "the most dreadful punishment imaginable." He says:

"The tunding I received in the fracas, a month ago, had no such terrible effect as imagined. Played football after two days without the least inconvenience. Ground ashes not as 'tough as whalebone,' but slight sticks rarely lasting for more than three or four strokes. The punishment I received is universally admitted (and readily by the prefect himself) to have been excessive; yet I firmly believe, as does every one else here, that there was no tyranny or brutality in the matter. On the contrary, it was done in an honest, though mistaken impression, that serious insubordination was intended by my refusal to obey him; hence, while his action may be condemned, he himself and his motives deserve respect," etc.

In the letters to his father, which are published, he states that he was little hurt; that he cared nothing for the "licking;" had contended for a principle, and, when this was decided against him, he went promptly for his tunding. The prefect wanted to "argue the case," but he told him he had come for his "licking," and wanted it at once. It had since been admitted, on all hands, that the vote was wrong, and the punishment excessive in the number of strokes, but he was thoroughly disgusted with the fuss made over so small a matter.

In the course of the discussion, the "father of the victim" states that he had written Dr. Riddle (head-master of the school) immediately on hearing of the case, asking that the prefect be required, at least, to make a public apology to the boy. The doctor replied in a letter of twelve closely-written pages, admitting and deploring the facts, which were the result of "grave error of judgment and zeal for discipline." Not satisfied with this, he (the father) called a bishop into counsel, through whose intercession Dr. Riddle wrote again, saying the prefect had apologized to "the victim" in his presence, and adding, somewhat reprovingly, that the matter were better left where it was. He wrote again, offering to let the matter drop, if the apology

were made known to the school. This letter being unanswered, after three weeks he resorted to the press.

These letters and statements subjected the system to a sharp discussion. "C. F." thinks the system not a bad one, if two things are clearly understood, namely, that an appeal will always be heard, and the prefect's punishing be limited to six cuts. The first rule would check abuse of power; the second would enable the prefects to settle many offences "out of court," thus preventing the brutality sometimes disgracing schools. "M. A. Oxon" was at Winchester five years during the "peaceful times," spoken of by Mr. Lechmere, and could testify that the "tortures of tunding" were then not infrequent. For "going out of bounds during play-hours," he and others had once undergone a prefect's tunding, in which he received twenty-five to thirty cuts, "laid on with such a will" that his jacket was cut to ribbons, and was never worn again," and his "arms and back were black and blue with wheals. . . . We were not, however, milksops in those days, and we bore with Spartan fortitude, and without a murmur, a punishment which now makes a cowardly, rascally 'garroter' howl and cry to the attendant surgeon for mercy." He had, however, hoped, until enlightened by Mr. Maude, that these tortures were gone by—the relics of a less civilized age. He describes the system as it was in his day, and adds that, while he endured it and was none the worse, he would not like to have a child of his subjected to a similar discipline. "W." gives a chapter of his experience, from which it appears that he was subjected to the bullying of his school-fellows. He states that he can give many instances of "prefect tyranny." "An Older Wykehamist" answers "An Old Wykehamist," and asks, "What's the use of an appeal *after* a thrashing?" and adds that an appeal before would provoke the ire of the prefects and the jeers of companions. He states that it was only three years since a prefect tunded, at one time, thirty or more boys for some trivial offence, and that he himself had received more than one hundred and sixty tundings, of from four to sixteen cuts each, in seven and a half years' attendance at Winchester!

Mr. Maude writes a second letter, answering the charges of "exaggeration." He reasserts that there is no limit to the power exercised by the prefects, and shows that the right of appeal is of little value. He gives cases showing the barbarity of the system. About fifty boys were "licked" one afternoon for being absent from an "irregular" roll-call, "the floor of the room looking like a fagot-yard." The headmaster disapproved of the irregular roll-call, but excused the prefects "on the ground of an excess of zeal in performance of duty!" In one case the prefect gave a boy several cuts on the face ("facers"), because he was supposed to be "padded."

Edmund D. Wyckham states that he frequently witnessed abominable cruelty in the "peaceful times" of Dr. Williams; once saw a boy tunded with a cricket-stump and lamed for life. The boys, on

this occasion, rebelled, rescued the victim, and fell upon the prefects, and cuffed and kicked them out of the Commons' Hall. After the boy had sufficiently recovered, he was publicly flogged by Dr. Williams for having resented a prefect! "An Old Winchester Prefect" gives similar testimony, and adds that the system is "an indefensible and barbarous practice," which should be ended at once and forever."

The system is as vigorously defended. "An Old School Disciplinarian" believes tunding to be infinitely better than caning by a master and less dangerous than knuckle-hitting on the head; "save me from sly kicks and boxes." The system creates good feeling between the seniors and juniors—gives the former responsibility; the latter protection from bullies—and is "a good training for the world." Instead of making boys "weak milksops," it makes them "Englishmen like their ancestors." "A Wykehamist" is proud of the old school, and believes that prefects are high-minded, deliberate, and just. His family had been connected with Winchester for fifty years, and he had never before heard a complaint.

"W." thinks the less a master "thrashes" the better—it takes a rare man to counterbalance the mischief done by "perpetual lickings." When the boys do the flogging, the result is very different. They know each other's tricks and ways, and can be more just. The system protects boys from brutality. When in school he was brutally kicked by a big bully whenever sent above him in class. Such treatment was not possible at Winchester. "*The great distinguishing character of every judiciously-managed English school is, that the boys are sure of being properly kicked!* . . . By all means let the masters *control* the system and effectually punish its abuse, but as 'kicking' will go on in every big school, let my boys go where it is reduced to a system, in the hands of a recognized class."

"A Civilian," one of Dr. Arnold's Rugby boys, is gratified that, while many see no cure for the abuse of the system but its abolition, others see a good use in the government of the public schools through prefects. He was six and a half years at Rugby, and only knew two or three cases of gross injustice or cruelty, but remembers scores of cases of sharp caning of "fags" for impertinence, neglect of duty, etc. "This punishment was infinitely preferred to one hundred lines of Homer or Virgil." Under this system, hundreds of boys govern themselves "without the continued interference of the eminent man at the head of the school."

"Expertus" contrasts, at length, the monitorial or prefectorial system with the "system of lock and key, usher and spy, and Jesuitical surveillance." While the former is liable to abuse and needs to be carefully guarded, it is "wonderfully strong in the argument from general success, from the characters which it has helped to train, and from the qualities it has naturalized in Englishmen."

A former "Acting Head-Master at Rugby," Sir Bonamy Brice,

also thinks that the excellence of the system has been abundantly proved by its success. To train great schools to govern themselves is a task of great responsibility, and mistakes will occur, as in all human government. He asserts that it would be easy to array a terrible catalogue of abuses or failures in the opposite system.

A number of other letters, *pro* and *con*, have been published, among them a card by Dr. Riddle, stating that the whole matter had been referred to the Governing Body, then in session, for examination and action. The decision, which we have not yet seen, was looked for with great interest when our correspondent wrote. It is probable that this discussion will result in a modification of the monitorial system, but we do not look for its immediate abolition. It is too characteristic of the English people.—*The National Teacher.*

THE HORNED FROG.

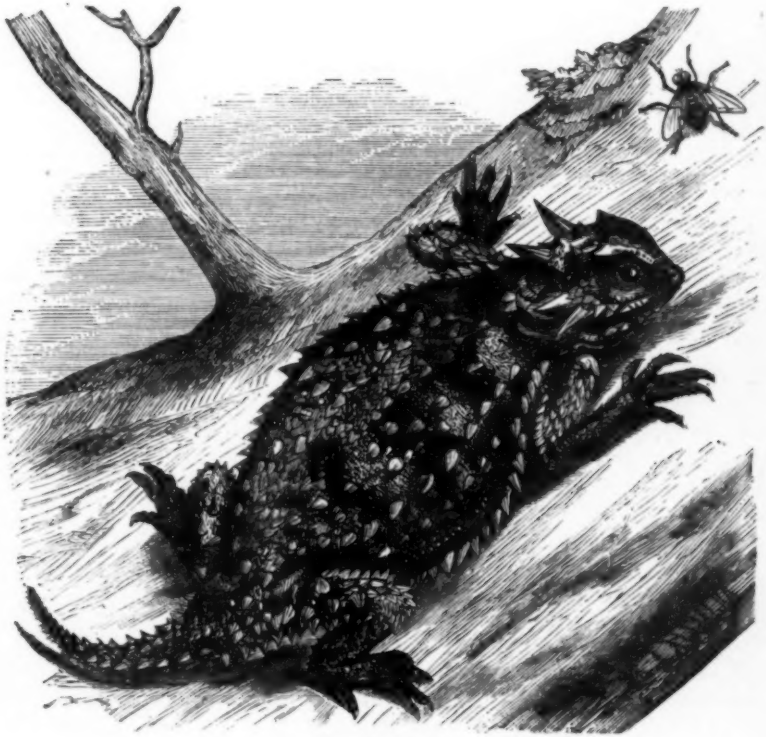
By FRANK BUCKLAND.

IN July, 1872, a sensational paragraph went the rounds of the papers that a "horned frog" had arrived at the Zoological Gardens; so I went to see it, and here, kind reader, you have a portrait of this celebrated animal.

In the first place, any one can see that the little beast, though carrying horns, is not a frog at all, but a lizard. It rejoices in the name of the "Crowned Tapayaxin" (*Phrynosoma cornutum*), from φρυνος, a toad, and σωμα, a body. This is not a bad name when it is construed, for it really is very like a toad in general appearance. It belongs to a family of Saurian reptiles (*Agamidæ*), this species being widely distributed in Asia, Africa, Australia, and South America. Why Nature has made these little creatures so hideous, as some would call them—though I call nothing hideous—I do not know. The *Moloch horridus* of Australia is also covered with spines, and looks even more formidable than our friend the horned frog, and yet they are quite harmless, and will hurt nothing but insects. If the fly in the picture is not speedily off about his business, Mr. Horned Frog will snap him up before, as the Yankees say, "he knew what hurt him." Holland, the civil and obliging keeper at the reptile-house at the Zoological, took the horned frog out of his box, and, as he sat upon my arm, I made notes about him.

Imagine a large bug, about four inches long and two inches across, with a tapering tail, which he can cock up after the manner of a scorpion, or the beetle known as the "devil's coach-horse," and you have some idea of the "Crowned Tapayaxin." The body is very flat, though, I believe, he can blow himself out quite fat if he likes, like the

frog in Æsop's fables trying to make himself as big as a cow; and he is covered all over with a number of spines, which are not unlike the spines on a blackthorn-bush. The edges of the flattened body are armed with a row of sharp prickles like the teeth of a saw; the head, which the little beast twists about in a Punch-like manner, is separated from the body by a short neck. Near the nape of the neck there are two sharp-pointed horns directed backward; the sides of the neck are armed with three or four shorter horns, so that the animal appears to have on a collar such as we see depicted upon the necks of wolf-hounds



THE HORNED FROG.

in Reidinger's splendid old German hunting pictures. The general color is like that of the toad, and he has a mottled belly, like that poor old toad about which so many "crammers" have been told relative to his being found buried in coal, stone, trees, etc.—antediluvian toads, "who swam about in the limpid streams wherein Adam bathed his sturdy limbs," etc. Toads, nevertheless, will stand a deal of burying; and so will horned frogs, for the individual whose likeness is now before you came by post all the way from Santiago, in Southern California. He was packed in a thin pasteboard box, and it is a wonder

that he had not been smashed by the metal stamp-obliterators of the post officials.

By-the-way, curious things are sent me by post. Every week I receive fish of some kind or another by post: young salmon, young trout, young whitebait; also young pheasants, three-legged kittens, six-legged kittens, no-headed kittens; and they generally smell frightfully. The postman always knows my letters without reading the address. Sometimes live things are sent me by post. I lately received a scorpion, caught alive at Woolwich. He was packed in a jeweller's box, and when he arrived was poisonous enough to sting a mouse severely; and, once, some kind person killed a viper, and put him into a paper sweet-stuff box; but, during the journey, the scotched viper came to life, and had to be killed again by the post-master-general, who wrote me an official note about it. I once heard of a pair of jack-boots being sent by parcels post. What next, I can't tell. Send what you like, my friends, only pay the postage, and, if you send vipers or scorpions, kill them first.

When at home, the habits of the horned frog are, I believe, very much the same as the toad's, lurking about stones, ruins, rocks, etc. Their spines, I believe, are given them for neither offence nor defence, but simply for the purpose of concealment from their enemies. The polar bear among the icebergs wears a coat as white as snow for concealment. It is exceedingly difficult to distinguish a sitting partridge when crouched down in a ploughed field. The tiger carries stripes like the jungle. The grouse is like the heather. In fact, most animals have coats given them to conceal them from their enemies, and it is more than probable that the spines of this little lizard serve for the same purpose.

I do not observe that in the so-called educational programme the subject of natural history is in any way introduced. This is, I think, a great mistake. Children and young people are naturally fond of animals, but they are too often brought up to kill and destroy any thing that looks, as they call it, ugly. I have known ladies scream, and even sometimes nearly faint, if they see an unfortunate spider, and then they go and kill the spider. Others are afraid of mice, frogs, and other harmless creatures. If these individuals had in their youth been taught how there was "evidence of the power, wisdom, and goodness of the Creator" in all created things, they would look upon these common ones with wonder and admiration, instead of being foolish enough to be frightened—or pretend to be frightened—at them.—*Leisure Hour.*

ON THE TRANSFUSION OF BLOOD.

By GUSTAVE LEMATTRE.

TRANSLATED FROM THE FRENCH, BY A. R. MACDONOUGH, ESQ.

IN all ages the most different opinions as to the seat and the principle of life have been expressed; yet, the systems bequeathed to us by the ancients on this subject contain a general belief, simple enough to be very widely shared, and seemingly well founded enough to endure for centuries. One fact of commonest observation—death resulting from hæmorrhage—gave rise to the notion that life dwells solely in the blood. Homer's heroes breathed out their souls with their blood; among the Hebrews, as among the Greeks, offering the sacrifice of a life, and shedding the blood of a victim, were equivalent expressions. On this point the religions of the West have consecrated the belief of all ages and all people; a verse in Leviticus thus sums it up: "The life of all flesh is in the blood."

From Galen to Harvey, men of science supposed that the heart only sends out the fluid of the blood from the centre to the surface. In their theories, the blood was incessantly formed and renewed within the liver, and was impelled by centrifugal force into the veins and arteries alike. Harvey first demonstrated that the blood returned in its course. "It moves," he said, "in the same circle, as the planets all describe the same orbit in moving through space." The idea of the transfusion of blood takes its starting-point from the discovery of Harvey. As soon as it was known that the blood can return to the heart, and be taken up again by the vessels, what was more natural than to seek to introduce it into a diseased body? Is not the blood still regarded as the sole principle of life, as it was in the early ages of medicine? And, since it can be transfused in kind, we shall be able to restore health, to heal disorders, perhaps, even to lengthen life. In a moment of pride the human mind believes it has penetrated the secret of life, and supposes that henceforward it will be its master. The most famous alchemists of the middle ages never surrendered themselves to hopes so wild. Besides, the sixteenth and seventeenth centuries saw the birth of so many discoveries in natural sciences, that nothing seemed impossible. The schools of medicine enter with feverish ardor on these questions, so full of promise; but, amid the light that bursts upon them, they often neglect that severe observation of facts which led to the discovery of the circulation. Physicians of that day trouble themselves very little with inquiries whether the ancient notions about the blood are true or false; they accept them without reserve, and publish them abroad with those forms of discussion and those obsolete principles which brought upon them the well-deserved

ridicule of our satirists. Medicine and physiology in that era were treated under the form of philosophic argument, science and imagination were blended, and "reasoning banished reason." The history of transfusion, at its beginning, looks like an important but empirical discovery; new experience rests simply on scholastic discussions, the true mingles with the false, and, after the spectacle of a barren contest presented by detractors and enthusiasts, transfusion was proscribed, and doomed to oblivion; and it will be long before its recovery, for the true scientific method has not yet been found.

In the last half-century we have returned to the method of observation; nor is that method now, as it was in Harvey's time, the privilege of a few *savants;* it has become the guide of all men of science in our day, and the real cause of scientific progress. Amid the general development of the sciences, transfusion has come up once more, transformed and widened; it will not satisfy the extravagant hopes indulged at first, but it will throw a broad light on the problem of health and disease. The principles on which this grand experience now rests are well settled—the functions of the blood have been clearly determined. We know that life dwells in every fragment of our being; the mass of nerves, the flesh of our muscles, the tissue of our glands, need the indispensable assistance of the blood, yet live by themselves. If general anatomy has followed out the work of Bichat, in studying the elements of dead Nature, physiology has realized Haller's conception, in analyzing the functions of these elements. Comparative study of animal and vegetable organization and the independent development of the tissues, after the evolution of the germ, has supplied general views upon the life of the parts; physiological dissection on the living animal, and particularly the mode in which poisons act, has completed the former results, and shown that each element in the organism has its individual activity. The experience of transfusion gains greater importance at this day, proportioned to the advanced state of science. Transfusion is not simply an operation practised on man; it finds its peculiar reason for existing as a process in scientific investigation. By it the properties of tissues and organs are analyzed, the independent life of the elements is once more made plain, and, when the secrets of the mechanism of our organization have thus been laid bare, transfusion is no longer an experimental remedy—it has become a process of reasoning.

At a time like our own, while the movement of minds is turning, with almost exclusive devotion, toward the justly-valued labors of Germany, it is not without interest to recall a course of discoveries peculiarly French. The history of transfusion in the nineteenth century, after the account of the fruitless efforts made in the seventeenth, has the advantage, besides, of allowing us to judge of the worth of methods by the nature of their results. These scientific triumphs of late date have hitherto been preserved only in special publications; but

they are of too general an interest to be reserved for physiologists and physicians; they must enter into the wide domain of Science.

In the order of scientific facts a great discovery never remains isolated, but opens unknown horizons, and leads to useful applications, by the conquest of new principles. No one, nowadays, is ignorant that the labors of Ampère in electricity and magnetism created the telegraph. In Harvey's time, circulation was accepted, spite of protests by the faculty and the disciples of Galen; a genius like Descartes publishes it in his famous "Discourse on Method;" demonstration by experiment confirms the position of theory in every point; and the most important consequences immediately follow. They affect the knowledge of drugs and poisons, the anatomy of man, and the medical art that heals him. It was easily understood that medicinal and injurious substances will act more promptly if introduced directly into the vessels, and Fabricius, a doctor of Dantzic, infused purgative salts into the veins. Fracassati, a professor of anatomy at Pisa, injected alcohol, spirits of vitriol, oil of sulphur and of tartar. These experiments did not advance the healing art much, but they led to one important consequence, probably unlooked for by their authors: they were the commencement of a process which allows us to study the nature of poisons; and the history of poisoning afterward took a new direction.

To the physician and the anatomist the process of transfusion was directly and immediately useful. A century earlier, the illustrious Andreas Vesalius had created human anatomy; after the publication of Harvey's works, the arteries and veins were studied in preference. In the class-room where dissections are going on, it is out of the question to transfuse living blood; but, for the advantage of following the course and distribution of the vessels, it is useful to inject them with such colored matters as will solidify. The Dutch Frederic Ruysch is the leader in this advance. In the land of Rembrandt the art of harmonizing colors aims not merely to bring the human countenance to life again on canvas; the anatomist of Leyden so well understands the secret of injections that, by imparting color to the interior of the tissues, he will restore the semblance of life to inanimate bodies; when, near the end of his long career, Ruysch put to press in Amsterdam the remarkable book in which he describes the wonders of the anatomical museum of his native town, like an artist content with the perfection of his work, he exclaims, at the first page, "I have babies there that have been embalmed for twenty years; they are so rosy and fresh that you would say they are not dead, but asleep."

Ruysch's anatomical preparations, of which the secret is now lost, were contemporary with that marvellous experience, also founded on the discovery of Harvey—we mean transfusion of actual blood. About 1660 the notions in medicine of the ancients were strongly and per-

sistently maintained, the blood more than ever believed to be the principle of life, and, with the knowledge of its circulation in the organism, comes the suggestion "to transfer blood from a young to an old person, from a healthy to a sick one, from cold to warm, from bold to timid people, from tamed to wild animals." But Galen's words are fully accepted; the theory of "animal spirits" rules unquestioned, and Descartes has given the system new vigor. That philosopher holds that there are in us two things—the spiritual life, comprising the soul, and the material life, formed by *spirits*, which he ingeniously compares to the restless particles of a wavering flame An unknown disciple of the great master, De Gurue, maintains the ideas of the new school in speaking of the transfusion of blood. "The blood of animals," he says, "containing a great quantity of *spirits*, cannot be mingled with that in the body of another animal of the same kind without fermentation, and cannot ferment without causing fever." For some persons, as Martin de la Martinière, the transfusion of blood is a barbarism, and those who practise it are "butchers and cannibals." Others think of it, with Eutyphronis, that it errs by oversetting traditions. This "practice," he says, "cannot be allowed, short of altering all ancient medicine." The partisans of bleeding, disciples of Guy Patin, thought that transfusion of blood would overwhelm the patient, and increase what should be taken away from him. The eclectics, in fine, believe that this operation brings its supporters and its opponents into agreement: the first, because it carries off corrupt blood; and the last, because, by the supply of new blood in place of that removed, the strength of the patient is not lessened.

All these theoretical discussions might have continued forever, had not Dr. Denis cut them short in 1667. He looks for the solution of most questions in physics by experience, not by argument. Zeno affirms that every thing in the world is immovable. Diogenes walks, for his only answer. Denis allows no other rule of action; he will not lose time in refuting the reasons of those who have written against the operation, but will oppose them by experience alone. The first two transfusions successfully practised on man are recorded in "a letter written to M. de Montmor, privy councillor to the king, and chief master of requests, by J. Denis, doctor of medicine, professor of philosophy and the mathematics." It is worth while to introduce, in few words, the eminent man to whom this work was addressed. M. de Montmor, a member and one of the founders of the French Academy, lived in the centre of scientific movement. Gassendi honored him with his friendship, and when that learned philosopher died, after many personal labors in the most varied branches of knowledge, De Montmor published a complete edition of his works. In the years preceding and following the foundation of the Academy of Sciences, before and after 1666, his house was a centre at which physicists and *savants* gathered every week to discuss the interesting questions of the day, and the

society thus formed had its rules intended to aid the progress of science. A few years before, a Benedictine monk, Robert des Gabets, had preached a sermon there on transfusion of the blood. The king's councillor took interest in a discovery of which he foresaw the range, and gave the new experimenter the support of his influence.

"The first trial," Denis says, "was made on a young man, fifteen or sixteen years old. This youth was attacked by a slow fever, for which the doctors had bled him twenty times. He had become dull and sleepy, from the treatment, to the point of stupidity. Some little warmth was felt during the operation. Eight ounces of blood were taken from him, and arterial blood from the carotid of a lamb was immediately introduced by the same opening. He got up about ten o'clock, dined with excellent appetite, and went to sleep at four in the afternoon. He bled slightly from the nose."

This operation having succeeded, Denis tried a second, but more from curiosity than necessity this time. The author relates it himself as concisely as before. "The transfusion was effected upon a chair-porter, of vigorous constitution, forty-five years old. Ten ounces of blood were taken from him, and lamb's blood substituted. The man complained of no pain during the operation, and was delighted beyond measure with the new invention, which seemed to him very ingenious. When it was all over, he declared that he never felt better. Employment offering about noon, he carried a sedan as usual for the rest of the day. Next day he begged that no one but himself might be taken as the subject of new experiments."

Three years before, transfusion of blood had been practised by Lower in England, but only on dogs. Denis repeated with these animals the experiments he had made on men. These were varied in the most interesting ways. He not only transfused the blood of one animal into the veins of another; but, from the 8th to the 14th of March, in 1667, he caused the same blood to pass into three different dogs successively. Granting the correctness of the views then prevalent, he then realized the famous Pythagorean fable of the transmigration of souls. The experimenter was also bent on making his discoveries generally known, proposing to make trials in public, and, for this purpose, he fixed for the first day of his lectures "Saturday, the 19th of March, of the same year, at two in the afternoon, on the quay of the Augustins." History does not inform us whether Denis carried out his plan; but the *Journal des Savants* gives a tedious account of a controversy that broke out more fiercely. In this previous war of ideas, facts are neglected and forgotten, arguments are only dealt with, and they control opinions. Denis declared at the outset that he would depend solely on experiment; but, at the same time, with a contradiction explained by the tendencies of the times, he comes forth into the scientific arena with the usual weapons—he discusses. The works devoted to this warm contest are all inserted in the *Journal des Savants;*

and such pages, long ago forgotten, show into what extravagances the fancies of the so-called scientific mind may be betrayed. Reading them, we involuntarily repeat the poet's line:

"The learned fool outfools the fool untrained."

The absurd was carried to its farthest limits in the arguments of a master of arts of the Paris University, named G. Lamy. "Since the blood of a calf," he says, "is made up of many different particles fitted to nourish the different parts of the body, if this blood is thrown into a man's veins, what will become of the particles of blood intended by Nature to produce horns? The case is not like that of a calf's flesh used for food, because those particles that are unfit for man's nourishment are altered in the stomach by coction. In the next place, since the mind and habits usually follow the bodily temperament, there is danger lest the blood of a calf, transfused into a man's veins, may give him also the stupidity and brutal dispositions of that animal."

Lamy finds followers among the opponents of circulation, his argumentative deductions are connected and consequent, but his starting-point is arbitrary and wrong. It is true his adversaries' reasoning is to blame for the same fault, but it will be accepted, if for nothing else, because it is addressed to those innovators who follow Harvey. A fragment of one of Denis's letters, on the question of the transfusion of blood, is worth quoting: "In the practice of this operation we only copy Nature, which, for the support of the embryo, makes a constant transfusion of the mother's blood into the child through the umbilical cord. Applying transfusion is only feeding one's self in a shorter way than usual; that is, it is putting ready-made blood into the veins instead of taking aliment that will turn into blood after several changes. The blood of animals is better for men than men's own blood; the reason is, that men, being agitated by various passions, and irregular in the way of living, must have more impure blood than beasts, which are less subject to such disorders. Corrupted blood is never found in animals' veins, while some corruption is always noticed in men's blood, how healthy soever they may be, and even in that of little children, because, having been fed with their mother's blood and milk, they have sucked in corruption with their nourishment."

All these quotations are curious, though they express mere obsolete ideas, because they show how far from the mark scientific discussions may wander, if they rest only on argument. Once started on that road, transfusion of the blood could run no long career. It yielded in a singular way. An isolated fact was enough to cause its fall. One of Dr. Denis's patients went mad after undergoing the operation of transfusion. His adversaries seized this accident as a weapon, and, Denis not having a diploma from the University of Paris, they procured a condemnation of the new doctrine. Transfusion suffers the same fate as antimony, a century later. On the petition of the Faculty

after decision by the Parliament, Du Châtelet, the deputy prosecutor, publishes an edict proscribing it in the name of the law. What was the real cause of the downfall of the system? That it rested on mistaken physiological ideas. The blood was still regarded as the sole principle of instinct, intellect, and life. The physician who practised transfusion could only defend it by hypotheses, and justify its employment by explanations and reasonings. The labors of our own time alone can give it lasting life; transfusion will revive two hundred years later to a new and vigorous existence, for it will rest on the best-established truths of physiology.

The light thrown by Harvey upon the knowledge of life did not give a complete account of the mechanism of our organization; the opening of an era of progress by grand discoveries awaited the coming of Lavoisier, at the close of the last century. General physiology was founded at that period, and the office and functions of the blood were soon learned by degrees and clearly settled. Between 1815 and 1830 the history of transfusion passes into a new phase. Atwood, Blundell, and Diffenbach, make it generally known by important works. In France two eminent *savants*, Prevost and Dumas, devote themselves to new researches, of which the "Annals of Chemistry," for 1821, preserve the record; but the transfusion of blood has made decisive steps only within the last twenty years, due particularly to the labors of a modern physiologist, Brown-Séquard. We shall sketch the bold and interesting experiments he employed in attacking and dealing so successfully with the most difficult problems of life; the history of physiology hardly presents a more exciting and instructive page. For its full comprehension, the nature and functions of the blood must first be explained.

As it circulates within the vessels, the blood is to be regarded as a fluid in which an innumerable quantity of colored corpuscles are floating. On account of their shape, these little bodies are called globules, and they are invisible without the aid of magnifiers; in fact, their diameter scarcely exceeds two ten-thousandths of an inch. The vehicle of these globules has the scientific name of *plasma;* the matters elaborated by the digestive apparatus, and the products of decomposition of the tissues, are the essential components of this liquid; albuminoid substances, analogous to white of egg, fats, sugars, salts of a mineral nature, appear in it under different forms, and constantly repair it; while the excretory ducts as constantly carry off from it those particles that become useless to life. The elements of our tissues have their nutrition kept up by a constant movement of supply and withdrawal, new molecules replace the old ones, and acts of assimilation and disassimilation find by turns in the plasma their point of origin and completion. The blood-globule is nourished just as the constituent parts of the glands, the muscles, the nerves, and the brain

are, and the only difference to be noted in this respect is that the process takes place within the very plasma itself, while the other elements are parted from it by the thin membrane of the capillary vessels. The globule has so distinct an existence of its own, that the chemical principles composing it are not found in its plasmatic medium. The various reactions shown by these little bodies in presence of chemical agents lead to the belief that they are found in the plasma in all stages of their development; their dimensions are not the same at the different ages of our organization. When the human germ is in process of evolution, the first lineaments of the vessels are traced in the depths of the tissues, and the heart begins to beat; the sanguine fluid is then formed, but the globules it contains are much larger than they will be after birth and in adult age. During this embryonic life the newly-formed blood does not communicate with the vessels in the maternal system—the two circulations being juxtaposed, but independent; there is not, as the belief in the seventeenth century was, a natural transfusion of the mother's blood into that of the embryo, because the solid particles or globules of each circulate and remain in each of unequal size. The study of the blood-elements in the animal series is interesting; they are found larger in fish and reptiles than in birds and mammals, whose vital activity depends on other powers. In spite of the resemblances presented by the sanguine fluid in these different groups, the blood of a fish could not vivify the body of a reptile for any length of time, nor could a bird's blood be substituted for a mammal's. The animal species whose nutritive fluid is mutually transfused must be closely related as regards natural classification: the globule which emigrates into a foreign medium can only become acclimated there in so far as its conditions of existence are not profoundly modified.

The blood-globule not only lives its individual life within the plasma, but it needs, in order to complete its function of vivifying every part of the body, to absorb oxygen from the air, and it then takes that bright vermilion color which is characteristic. The phenomenon of that new coloring is an essentially vital act, a chemical reaction taking place between two bodies, one solid, the other gaseous. Precisely the same thing happens with the commonest copper coin placed in contact with the air—it absorbs a gas, and its surface is soon covered by a colored product. In the lower animals that have copper in their blood, the vine parasite, for instance, the globules take a bluish color on contact with air. The same phenomenon is remarked in the vegetable kingdom; indigo, which is white in the plant, turns blue when exposed to the air, and many coloring substances are formed in the same way. The red globule contains iron, and the chemical action taking place in it may perhaps be compared to the formation of rust. Exposed to atmospheric air, it takes a dark-red color, while continuing crimson in the arteries. Deep in the tissues, the

oxygen of the globule is disengaged; combustion occurs with production of heat, but without flame, as is the case with starch; the blood becomes venous and darkish; then, sent back to the vessels of the lungs, it resumes its arterial coloring with the vital air.

In connection with the history of transfusion it is important to know the quantity of blood contained in the organism; this has been estimated, by approximation, and attempts have been made to ascertain it in the human subject. A criminal named Langguht was beheaded at Munich, July 7, 1855: about eleven pounds of blood were collected by Professor Bischoff. The weight of the body was one hundred and forty pounds; the proportion of blood being one thirteenth. This estimate has been accepted by many physiologists, although some believe it is too low. Nothing certain can be arrived at on the subject; does not the quantity of blood in our bodies vary according to very many conditions? It does not remain the same before and after eating, while asleep and while awake. In hibernating animals, as the marmot, or the dormouse, if the weight of the body decreases one-fourth in the period of rest, that of the blood is considerably reduced. The same fact is observed in fasting, the globules losing size and color. Disease produces a similar result, and nothing is more correct than the commonly-held opinion that "grief and privation consume the blood." The precise ideas we now have of the nature of this fluid have largely corrected Broussais's errors, and more than one practitioner in our day would assent to Galen's precept, that "in bleeding the measure of a half-pint must not be exceeded, and in any case the veins of a patient under fourteen must be spared." The study of transfusion proves the importance of the sanguine fluid better than any general considerations. We shall presently point out those well-settled cases in which the physician may practise the operation; but the reader is now prepared to understand how each part of the body derives supplies of life from contact with this fluid. The functions of the tissues will be briefly analyzed in turn; glands, muscles, nerves, spinal marrow, brain, will display their special activity. We shall see how the blood-globules feed singly all these flames, which blend and mingle to light the torch of life.

Secretion takes place by means of the glandular tissue. This function is connected with nutrition, and in the lower products of organized matter is identical with it. The simplest vegetables, and the lowest animals, are instances of this blending. In the higher degrees of animated beings, the elements of secretion separate and maintain their own life, finding in the surrounding air or the moistening fluids the conditions of their nourishment and work. In perfect organizations the glandular tissue becomes more complex, receiving nerves and vessels; natural transfusion of the blood begins to play an important part. The size and secreting energy of the glands are directly related to the quantity of blood passing through them; thus the kidneys, in-

cessantly at work, have a highly-developed arterial system. The blood is renewed in the glands as in all the tissues, and the dilatable walls of the vessels admit it in different proportions, according to the state of rest or activity of the organ. In this case, as in all others, particular facts are merely the expression of a more general law. The flow of blood increases when a stimulant exerts its action. When a glandular element acts with energy, it produces a high degree of fulness of blood in all the neighboring parts; and physiologists have thoroughly proved this fact in the case of the salivary glands of animals. In a state of rest, the congestion of these glands is slight, the blood dark in the veins issuing from them; the organ is then gaining growth. When the animal taken for experiment emits saliva under the influence of artificial stimulus, the glands, on the contrary, fill with blood, the vessels grow turgid, and take a high vermilion color. Thus variations in the supply of blood always correspond with degrees in secreting activity, and secretion ceases when the blood no longer comes to the glands. If the vessels of the liver are obliterated, bile ceases to be formed; if the arteries of the kidneys are compressed, secretion by those organs stops. The statement of the conditions of the problem suffices to suggest its solution; the blood is a medium whence the glands draw the principles of their growth and functions; the circulation of the sanguine fluid within the glandular tissue is a true transfusion kept up incessantly by the heart, and which only artificial transfusion can be a substitute for.

Nutrition and secretion by their constant work keep up the organized state of vegetable and animal matter. Plants possess only these two functions, and we may almost say the same thing as to animals while asleep; but these are not the only functions assigned to the waking animal, which comes into relations with the external world, through motion, sensibility, and intelligence. The muscular fibre, the special organ of motion, has its activity, independent of the nervous system; local transfusion confirms this scientific view, which now rests on manifold proofs. Like the secreting element, the muscular fibre is distinct in some lower animals; the microscope detects it in that state in the transparent body of the infusoria called vorticelli. In the higher degrees of the animal series this fibre is found in connection with nerves and vessels, and, though it enjoys an excitability peculiar to itself, it receives an impulse to movement from the motor nerve. The contact of the muscular fibre with blood-vessels is very close; but the chemical composition of the blood that moistens it varies according to the quantity of work yielded; thus it is indispensable that new fluid should be constantly transfused into the net-work of veins in the muscle. If the motor fibre is at rest, the blood passing through it is scarcely modified. If it is in a state of half contraction, the oxygen decreases in the blood, and the carbonic acid increases. If contraction is evident and powerful, combustion and production of car-

bonic acid are then at their maximum; the blood of the veins is extremely dark—the muscle is growing and acting both at once.

These are modifications which the muscular fibre undergoes during life. When death occurs and the blood is no longer renewed, muscular irritability disappears after a time which varies, and in an order which is fixed. The left ventricle of the heart first ceases to be excitable, then the intestine, the bladder, the iris, the muscles of animal life; the right auricle of the heart dies last; it is the *ultimum moriens*. The organic matter making up what is called the flesh decomposes, and is thenceforth governed entirely by chemical forces. The juices it contains become acid, coagulations take place, and then comes on the condition called by the name of corpse-like rigidity. Thus changed, the muscle is no longer excitable; but, if it is subjected at this instant to a current of arterial blood, it immediately revives, rigidity disappears, the muscle-fluids regain their former composition, and the individual activity of the fibre displays itself anew. Experiments establishing this great fact have been tried, not only on animals, but also on man even, and under circumstances that present some difficulty in the recital; the dramatic side of the subject is vivid enough to allow of a strictly scientific narration by itself. We will relate the transfusions performed by Brown-Séquard on two persons beheaded at Paris in June and July, 1851.

The first experiment was tried on a man aged twenty. He was beheaded at eight o'clock in the morning; eleven hours later all trace of irritability had disappeared from most of the muscles of the body. Injection into the muscles was begun at ten minutes past nine in the evening; the quantity of blood (which the operator took from his own veins) was enough for a limited part of the body; he therefore confined his experiment to the hand. Injection was made by the artery in which the pulse is usually sought, a little above the wrist, and, of course, in the direction of the fingers; it was urged at first quite fast, then slowly. The blood which went in bright colored, passed out dark from the vein, as is the case in life. The operation continued thirty-five minutes, and, ten minutes after that time, irritability had returned; a movement in the muscles of the hand could be artificially excited.

With the second subject, injection of the blood of a healthy dog was made; the blood had been first deprived of its coagulable matter, and beaten up in the air; there was about a pound of it. The subject was a strong man, forty years old. Death had occurred at eight o'clock in the morning; at twenty-five minutes past ten in the evening rigidity was complete, without a trace of contractility under the influence of stimulus. The arm was amputated, and at twenty minutes past eleven Brown-Séquard effected injection by the brachial artery. The skin at first took a livid color, but very soon the roots of the hair grew erect, giving the effect of goose-flesh, as it is called. This arti-

ficial circulation was so entirely successful that the veins on the back of the hand presented a bluish tinge; a beating like that of the pulse lifted the main artery of the wrist, muscular life revived; the fingers soon lost their stiffness, and at forty-five minutes after eleven irritability had reappeared in the muscles of the arm; it was still perceptible at four in the morning of the next day.

Experiment has never more clearly proved that the blood is essential to muscular life. In the limbs of these subjects the organic matter was decomposed, and all vital manifestation had become impossible. A flow of blood throughout them was effected, and at once this muscular flesh becomes contractile again; the special activity of the motor fibre is reanimated, and its functions performed as in life. It will, of course, be objected that the muscular element receives its conditions of activity from the motor nerves, and that the blood-globules only vivified it indirectly, by restoring excitability to the nerves; but has not the mode of action of *curare* proved that the life of the muscle persisted after the physiological death of the nerve? If the arteries of the lower limbs of a living animal are tightened by a compress, the withdrawal of the blood will in the same way cause the properties of the nerves to disappear before those of the muscles; an artificial stimulus, directly applied to the muscular fibre, will still produce movement, after nervous excitability has ceased to exist. If you then remove the compress, you set the flow of the blood free, and the peculiar action of the motor nerves is completely restored. Thus the life of the nervous element itself has been successively extinguished and revived; after that the inciting stimulus from the train of the spinal marrow may be transmitted through the medium of this conductor, which possesses a real autonomy.

The nerves of general sensation, like the nerves of motion, demand the contact of arterial blood. The anatomical distribution of these nerve-elements does not allow the action of the sanguine fluid upon them to be studied as to their surfaces; yet sensation constitutes too well-defined a function not to be the object of experimental analysis, as motion is; this analysis is made by the help of transfusion upon the spinal marrow, the organ that receives all impressions made on the skin. Physiologists have used an ingenious process to prevent the blood from moistening this nervous centre: they inject a liquid filled with an inert powder into the vessels, in a uniform direction; the capillary parts of the circulation are soon clogged, the spinal marrow ceases to be in relations with the blood, and ceases at once to receive impressions from the skin. The same phenomenon is observed when all the blood-vessels that go from the main artery of the body to this nervous centre are artificially destroyed; the return of sensation takes place only when arterial blood is restored to the spinal cord. This fact is also proved by the transfusion of new blood into the veins of an animal that has yielded to a hæmorrhage. Again, an-

other experiment, made in the following way, furnishes a proof of it. Two dogs were submitted to the section of the nervous centre which contains the *vital knot*, occasioning death. The appearance of death was produced as soon as the starting-point of the respiratory nerves was deeply injured. By slow degrees the nervous tissues lose their properties, and, before they are entirely extinct, the spinal cords of the two animals are exposed. One is subjected to the action of oxygen gas, and its sensibility increases; the other is influenced by hydrogen gas, and its sensibility remains unchanged. These facts show with absolute certainty that the nervous centres find their conditions of activity in the oxygen of the blood, or, to speak more precisely, the oxygen of the blood-globule.

The brain, the organ of the highest manifestations of life, performs its action like the spinal cord, and an elaborate net-work of blood-vessels distributes the nutritive fluid throughout all its parts. Yet the mass of the brain does not keep its functional activity constantly at work. The whole organism rests after the day's labor; the brain, when not waking, preserves only its life of nutrition; therefore the religions of ancient Greece, not without reason, regarded Sleep as the brother of Death. The quantity of blood transfused into that organ during these two conditions, so different, of sleep and wakefulness, is not the same. Dr. Pierquin had the opportunity of making observations upon a woman in whom disease had destroyed a large part of the bones of the skull, and deprived the brain of its membranous covering; the nerve-mass, quite exposed, shone with that brilliant lustre observed in all living tissue. While at rest in sleep, the substance of the brain was pink, almost pale; it was depressed, not protruding beyond its bony case. At once, when all the organs were quiet, the patient uttered a few words in a low voice; she was dreaming, and in a few seconds the appearance of the brain completely changed; the nerve-mass was lifted, and prominent externally; the blood-vessels, grown turgid, were doubled in size; the whitish tinge no longer prevails; the eye sees an intensely red surface. The tide of blood increases or lessens in its flow, according to the vividness of the dream. When the whole organism returns to quiet, the lively colors of the infused blood fade away by degrees, and the former paleness of the organ is observed again. The succession of these phenomena permitted the conclusion that increasing action of the cerebral cells attracts a considerable quantity of blood to them.

The general circulation in the brain is weak during sleep; in fainting it suffers complete suppression, and every one must have noticed the effects that result in this organ from the abstraction of blood. The least emotion, the smell of a flower, can bring on impressions that react on the heart, and for a moment suspend its movements; the blood then ceases to stimulate the brain, and paleness of the face indicates the bloodlessness of the deeper parts. The organism no longer puts

forth that outward activity which is peculiar to life; it droops, no intellectual manifestations occur, no impressions from light or sound are felt; but let a current of cool, fresh air touch the face, and life revives, the heart resumes it movements, color comes to the cheeks, and the phenomena of intellect and sensation reappear in the inverse order of their cessation. The English surgeon, Astley Cooper, produced similar phenomena in dogs by compressing the arteries of the brain at the neck; the animal fell into utter insensibility, and seemed to die. On suspending compression, cerebral life immediately returned; yet this was but an imperfect representation of what takes place in fainting. It was reserved for one of our own physiologists to go more deeply into the mechanism of the phenomenon. To bring life back again for a moment to a head severed from the body, and to restore it by the arterial blood, this was the problem which Brown-Séquard proposed and solved. The details of this memorable experiment were these: A dog is beheaded, and the head, still warm, separated from the trunk at the junction between the neck and chest. The evidences of life disappear by degrees, the eye losing its expression last. An electric current sent through the remaining part of the spinal cord no longer excites any contractions, the respiratory movements of the nostrils and lips cease entirely. After ten minutes have elapsed, Brown-Séquard adjusts to the four arteries of the head an arrangement of tubes communicating with blood deprived of its coagulable part, and charged with oxygen. By the help of artificial mechanism, imitating the action of the heart, the experimenter makes the blood circulate throughout the brain and spinal cord. A very few moments pass before irregular quiverings give life to the face, growing more decided, and at length movements reappear in all the muscles, and the eyes resume motion. "All these movements," says Brown-Séquard, "seem directed by the will." The experiment was continued for a quarter of an hour, and during all that time the vital manifestations and the appearance of their being voluntary continued. They soon ceased after the injection was stopped, and then followed the group of phenomena observed in dying, the pupil contracted and again dilated, and the last effort of life was a strong convulsion of all the facial muscles.

The naturalist experiences the strongest emotions at the sight of so extraordinary a spectacle. The physician now understands the necessity of contact between arterialized blood and the matter of the brain. He knows why a reclining position is proper in cases of fainting, giving easy access for the vivifying fluid to the brain. He knows that by throwing water on the face he will act upon the nervous centres, reanimate the movements of the heart, and cause circulation of blood in the mass of the brain. The philosopher asks himself one of those questions which are as old as the world, and more than ever of present interest, since the animated discussions of Barthez and Gabanis: Does or does not organized matter engender the phenomena

which it manifests? A grave problem, which Claude Bernard, in his admirable "Report on the Progress of Physiology," seems to us to have solved. That *savant* holds that the brain of the animal subjected to the experiment of transfusion of the blood acts like a complicated piece of mechanism upon the restoration of the blood belonging to it: the cerebral organ is only the instrument of the intellect, and the human machine marks life, as a clock marks time.

A physiological dissection, like that which transfusion of blood may be said, in some sort, to perform upon the glandular, nervous, and muscular systems, how complete soever it may be, has no value, unless the results of the analysis are combined; the experimental cutting up of the human body ought to end by recomposing the whole of it. That is the mode of procedure in the physical sciences. The colorless beam of white light is separated through the prism as it is by the drops of water that form the rainbow, and after passing through the glass it spreads into a wonderful gathering of colored rays. Each ray is studied in its properties, calorific, chemic, or luminous; then, when the work of analysis is ended, another prism directs all these rays in an inverse course toward convergence and the beam of colorless light is re-formed. It is so with the organism and its constituent parts. The individual life of the glands, the muscles, the nerves, the brain, is demonstrated by the aid of local transfusion, and the synthesis of the living being is accomplished at once by general transfusion. The blood coming from the heart is distributed into all parts of the body, no longer confined by art in a fixed space; thus the partial lives of the tissues and organs are simultaneously renewed, and the life of the individual becomes an admirable collective unity.

These important results, which the physiologist regards from the high point of view of theory, the physician meets on practical ground and in his patient's presence. And clinical triumphs have confirmed scientific views, which find their reasonable explanation partly in our knowledge of the normal life of the elements, partly in the morbid changes they are subject to. Transfusion of blood has sometimes served as an heroic remedy for arterial hæmorrhages, and losses of blood occurring after confinement. In these situations there is no injury to the elements of the nervous tissues, the glands and muscles; thus the supply of new blood restores life to them; it is replenishing a lamp, with its machinery all in order. When, on the contrary, the glands, muscles, and nerves, are changed in the first place, and the injury to the blood is the consequence of alteration in the tissues, instead of being its cause, transfusion cannot be as serviceable; it is almost always powerless; and, to repeat our comparison, the process is like pouring oil into a lamp more or less out of order in its inner construction.

Transfusion is not only employed to replace blood lost by a patient, but used also to substitute pure for vitiated blood. It is success-

fully applied to resist poisoning by carbonic oxide. This gas, formed by the combustion of charcoal and the oxygen of air, is a powerful poison. Breathed in moderate quantity, it induces death by well-defined action; the carbonic oxide, acting on the blood-globules, displaces their oxygen, and forms a stable combination with them, which is inert as regards vital properties. The constituent elements of the organs soon cease to act, and they die as they do after arterial hæmorrhage. For some hours, immediately after the poisoning, the blood-globules only are concerned, the other tissues remaining untouched; it will be enough, then, to restore a healthy state, to empty the vascular system, and replace the poisoned blood by new blood, and life will revive. Thus the history of transfusion once more proves that triumphs in the healing art may find their starting-point in the physiologist's table, as advances in industrial art often originate in the chemist's alembic.

In the centuries regarded as a whole, the epoch of Harvey and our own seem to belong to a similar period. The demonstration by physiology of the individual life of the parts, and the practical applications of transfusion, are wholly modern, as the circulation of the blood itself is. In ancient days the general belief was, that the life dwells in the blood, andyet some ancients seem to have had a suspicion that the elements of the organization live of themselves, and that, perhaps, the blood has a movement of circulation. Yet the ancients observed the life of the parts only in their outward forms. It is as a child studies the works of a watch: give it to him, and he is satisfied to hear it tick; open it, and he follows with his eye the movement of the wheels, but does not go further than to note appearances. Progress comes with age, and the child, seeing the same watch when he is a grown man, asks why and how it goes; taught by experience, by dint of perseverance and labor, he takes off and replaces every wheel, gains a precise idea of the mechanism of each part, and the arrangement of the whole is then clearly understood. Men of science in our times have studied the human machine so: the life of the parts has not only been observed, but traced and detected in its most secret machinery. Transfusion of blood, so useful in this respect, never acquired any true scientific importance in the seventeenth century. At first it appears as a universal panacea, aiming at the mastery of life, and triumph over disease itself. We have seen how the mere imaginings of that idle dream passed away. In our day the true method, the method of observation, is rightly honored, and scientific questions, no longer agitated with mere parade of eloquence, are modestly studied by their facts in the seclusion of laboratories. Transfusion again comes up, but not with its old extravagant pretensions; it no longer aspires to give universal, indefinite life. Reduced to the simple duty of a scientific process, it unveils the most mysterious secrets of the organization; it throws light upon the life

of the parts; it demonstrates that each element in the organism lives of itself, and finds in the blood the conditions required for its action.—*Revue des Deux Mondes.*

SCIENCE AND OUR EDUCATIONAL SYSTEM.[1]

By F. A. P. BARNARD, LL. D.,
PRESIDENT OF COLUMBIA COLLEGE.

MR. PRESIDENT: I am expected to deal, this evening, with a theme which, under the actual circumstances, it is somewhat difficult to handle. The degree to which our systems of education tend to foster or discourage original investigation into the truths of Nature is a topic which might better befit an assembly more gravely disposed than the present. *Dulce est desipere in loco*—it is pleasant to put on the cap and bells when circumstances favor, says Horace, and he says quite truly; but he does not say, *difficile est sapere inter pocula*—it is hard to imitate the solemnity of Minerva's bird, when champagne is on the board, as I think he ought to have said, and as he would, perhaps, have said if prosody had allowed, and which would have been equally true. I shall not aim at such an imitation. I do not mean to be didactic if I can help it. If I am so, I trust you will be indulgent.

I say, then, that our long-established and time-honored system of liberal education—and when I speak of the system I mean the whole system, embracing not only the colleges, but the tributary schools of the lower grade as well—does not tend to form original investigators of Nature's truths; and the reason that it does not is, that it inverts the natural order of proceeding in the business of mental culture, and fails to stimulate in season the powers of observation. And when I say this, I must not be charged with treason to my craft—at least, not with treason spoken for the first time here—for I have uttered the same sentiment more than once before in the solemn assemblies of the craft itself.

I suppose, Mr. President, that at a very early period of your life you may have devoted, like so many other juvenile citizens, a portion of your otherwise unemployed time to experiments in horticulture. In planting leguminous seeds you could not have failed to observe that the young plants come up with their cotyledons on their heads. If, in pondering this phenomenon, you arrived at the same conclusion that I did, you must have believed that Nature had made a mistake, and so have pulled up your plants and replanted them upside down. Men and women are but children of a larger growth. They see the

[1] Address at the Tyndall Banquet.

tender intellect shooting up in like manner, with the perceptive faculties all alive at top; and they, too, seem to think that Nature has made a mistake, and so they treat the mind as the child treats his bean-plant, and turn it upside down to make it grow better. They bury the promising young buds deep in a musty mould formed of the decay of centuries, under the delusion that out of such *débris* they may gather some wholesome nourishment; when we know all that they want is the light and warmth of the sun to stimulate them, and the free air of heaven in which to unfold themselves. What heartless cruelty pursues the little child-martyr every day and all the day long, at home or at school alike; in this place bidden to mind his book and not to look out of the window—in that, told to hold his tongue and to remember that children must not ask questions! A lash from a whalebone-switch upon the tender little fingers too eagerly outstretched could not sting more keenly, or be felt with a sharper sense of wrong, than such a rebuke coming across the no less eagerly extended tentacles of the dawning and inquiring intellect.

Now, a system of education founded on a principle like this is not going to fit men to engage successfully in that hazardous game of life in which, in Prof. Huxley's beautiful simile, we are all of us represented as playing with an unseen antagonist, who enforces against us relentlessly every minutest rule of the game, whether known to us or not. Still less can it fit them to bring to light new rules of this difficult game, never yet detected by any human intelligence. Yet it is precisely of this kind of men that the world has present need. For, grand as are the triumphs of scientific investigation already achieved, it is impossible to doubt that there are still grander yet behind to reward the zealous laborers of the time to come. I know that it sometimes seems to us otherwise; I know that the very grandeur of the achievements of the past makes us sometimes doubtful of the future; for it is generally true that the portals of Nature's secret chambers, yet unexplored, are only dimly discernible before they are unlocked.

I remember a time—it is now long gone by—when this skeptical feeling as to the possibilities of large scientific progress in the time to come was extremely prevalent—so prevalent that a learned professor of a neighboring college thought it worth his while to combat, in an energetic public address, the discouraging notion that Nature has no longer any important secrets to yield. Subsequent history has magnificently corroborated his argument. For that was a time when, as yet, no Faraday had drawn a living spark from the lifeless magnet; no Daniell, or Grove, or Bunsen, had given us an enduring source of electro-dynamic power; no Ohm had taught us how to measure such a power when obtained; no Bessel had detected the parallaxes of the fixed stars; no Adams or Leverrier had thrown his grapple into space, and felt the influence of an unseen planet trembling, to use the

beautiful language of Herschel, along the delicate line of his analysis; no Draper, or Daguerre, or Talbot, had revealed the wonders of actinism; no Mayer or Joule had laid a sure foundation for the grand doctrine of the conservation of force; no Carpenter had unravelled the intricacies of nervous physiology, or analyzed the relations of mind and brain; no Agassiz had ridden down the Alps on the backs of the glaciers and proved their steady flow; no Darwin had lifted the veil from the mysteries of organic development; no Schiaparelli or Newton had put the harness of universal gravitation upon the wayward movements of the shooting-stars; no Mallet had presented an intelligible theory of volcanic flames and of the earth's convulsive tremors; no Kirchhoff had furnished a key to the intimate constitution of celestial bodies or a gauge of stellar drift; no Huggins, or Secchi, or Young, had applied the key thus presented to enter the secret chambers of the sun, the comets, the fixed stars, and the nebulæ; no Stokes had made the darkness visible which lies beyond the violet; no Tyndall had done the same for the darkness beyond the red, or had measured the heat-absorbing powers of aëriform bodies, or shown how the tremors of the ether shake asunder the elements of vapors. In short, that period of presumed scientific omniscience seems now, as we look back to it, but the faint dawning of a day of glorious discovery, which we dare not, even yet, pronounce to be approaching its meridian.

How much of all this has been due to our system of education? Among the great promoters of scientific progress before or since, how large is the number who may, in strict propriety, be said to have educated themselves? Take, for illustration, such familiar names as those of William Herschel, and Franklin, and Rumford, and Rittenhouse, and Davy, and Faraday, and Henry. Is it not evident that Nature herself, to those who will follow her teachings, is a better guide to the study of her own phenomena than all the training of our schools? And is not this because Nature invariably begins with the training of the observing faculties? Is it not because the ample page which she spreads out before the learner is written all over, not with words, but with substantial realities? Is it not because her lessons reach beyond the simple understanding and impress the immediate intuition?—that what she furnishes is something better than barren information passively received — it is positive knowledge actively gathered?

If, then, in the future we would fit man properly to cultivate Nature, and not leave scientific research, as, to a great extent, we have done heretofore, to the hazard of chance, we must cultivate her own processes. Our earliest teachings must be things and not words. The objects first presented to the tender mind must be such as address the senses, and such as it can grasp. Store it first abundantly with the material of thought, and the process of thinking will be spontaneous and easy.

This is not to depreciate the value of other subjects or of other modes of culture. It is only to refer them to their proper place. Grammar, philology, logic, human history, *belles-lettres*, philosophy—all these things will be seized with avidity and pursued with pleasure by a mind judiciously prepared to receive them. On this point we shall do well to learn, and I believe we are beginning to learn something, from contemporary peoples upon the Continent of Europe. Object-teaching is beginning to be introduced, if only sparingly, into our primary schools. It should be so introduced universally. And in all our schools, but especially in those in which the foundation is laid of what is called a liberal education, the knowledge of visible things should be made to precede the study of the artificial structure of language, and the intricacies of grammatical rules and forms.

The knowledge of visible things—I repeat these words that I may emphasize them, and, when I repeat them, observe that I mean *knowledge* of visible things, and not information about them—knowledge acquired by the learner's own conscious efforts, not crammed into his mind in set forms of words out of books. Our methods of education manifest a strong tendency in these modern times to degenerate in such a sort of cramming. Forty years ago, the printed helps to learning, now supplied to the young men of our colleges in so lavish profusion, were almost unknown; and teachers lent about as little aid, at least during the earlier years, as books. What the student learned then he learned for himself by positive hard labor. Now we have made the task so easy, we have built so many royal roads to learning in all its departments, that it may be well doubted if the young men of our day, with all their helps, acquire as much as those of that earlier period acquired without them.

The moral of this experience is that mental culture is not secured by pouring information into passive recipients; it comes from stimulating the mind to gather knowledge for itself. When our systems of education shall have been remodelled from top to bottom, with due attention to this principle, then, if we have minds among us which are capable of pursuing Nature into her yet uncaptured strongholds, we shall find them out and set them at their work. Then neither "mute inglorious Miltons" on the one hand, nor on the other silent, unsuspected Keplers, nor Newtons "guiltless" of universal gravitation, shall live unconscious of their powers, or die and make no sign. Then the progress of science will no longer be dependent, as in the past it has been to so great a degree, on the chance struggles of genius rebelling against circumstances, such as have given us a Herschel, a Franklin, a Hugh Miller, or a Henry; nor will the world be any more astonished to see the most brilliant of the triumphs of the intellect achieved by men who have cloven their own way to the forefront, in defiance of all its educational traditions; as it has seen in the case of a Rumford, a Davy, a Faraday, and a Tyndall.

THE TROGLODYTES, OR CAVE-DWELLERS OF FRANCE.[1]

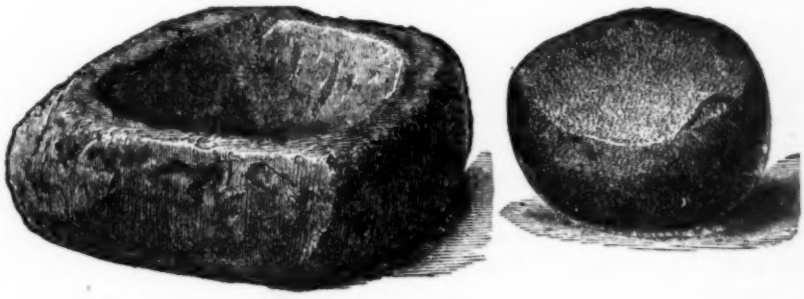
By PAUL BROCA.

TRANSLATED FROM THE FRENCH, BY J. FITZGERALD, A. M.

1. *Their Manner of Life.*

IN the southwest of France, at no great distance from the river Vézère, are situated the caves which were inhabited by a race of Troglodytes toward the close of the Quaternary geological period. The openings of these caves faced all points of the compass, except the north. They were inhabited throughout the entire year, as is shown by the remnants still found there of young reindeer, in every stage of development. From the teeth, bones, and budding horns of these animals, we can determine their age, and the season of the year when they were killed; and the evidence of this kind furnished us by the contents of the caves shows that the Troglodytes had a fixed abode; or, in other words, that they were not nomadic in their habits.

FIG. 1.



PESTLE AND MORTAR.

When the inhabitants of the caves went fishing or hunting, they closed up the door-ways to exclude beasts of prey. Only one bone has been found, and that at La Madelaine, which bears any tokens of having been gnawed by a wild beast. It shows the marks of a hyena's teeth, the animal having in some way gained admittance to the cave. Hyenas were scarce in the time of our Troglodytes, but wolves and foxes abounded; and we should find the marks of their teeth upon the bones strewed about in the caves, were it not that the inhabitants

[1] This article is a part of the elaborate address before the French Association for the Advancement of Science, by M. Paul Broca, one of the most eminent anthropologists of Europe.

kept their dwellings carefully shut against such intruders. But what were the means employed to keep them out? In sepulchral caves we find the entrance closed by a stone slab; but a dwelling-place would require a door more easily opened and shut than that. Besides, we find no trace whatsoever of stone doors, and therefore it is supposed that the Troglodytes barricaded their door-ways with hurdles.

They lived by the chase, and by fishing. But, did they use vegetable food? We cannot find any evidence that they did. There have been discovered, it is true, in the caves of Les Eyzies, Laugerie-Basse, and La Madelaine, a number of stones—granite, freestone and quartzite—worn round and smooth by rubbing, which exhibit on one side a pretty regular depression, in the form of a cupule, and not unlike a small mortar (Fig. 1). Some have supposed that this cupule might have been intended to receive the end of a piece of dry wood, which would then be whirled between the hands to produce fire, according to the well-known process in use among the ancient Aryans, and among some savage tribes of the present day. But the depression is too shallow, considering its diameter, to have served such a purpose, and hence we take these stones to have been mortars, while other round stones, of dimensions answering to the cupules, would serve as pestles. Hence came the supposition that the Troglodytes brayed grain for food: but every thing goes to show that they were unacquainted with agriculture. It is far more probable that they used the mortars to pound fish, or to grind pigments.

Their chief occupation and their principal resource was the chase. The remnants of bones accumulated in the soil forming the floor of the caves, show that they hunted animals of every size, from the little bird to the mammoth. That old giant of the early Quaternary period still survived, but had now become rare. For a long time it was supposed that the mammoth became extinct about the middle of that period; and when it was announced that several teeth of that animal and sundry pieces of wrought ivory had been discovered in the most recent Troglodytic stations of the Vézère, many persons were of opinion that these remains must have come down from an earlier period, and been gathered by our Troglodytes, just as the inhabitants of Siberia do at present. But it must be remembered that the carcasses of mammoths found in Siberia have been preserved by the extreme cold, and consequently their flesh and ivory are still fresh, whereas, *fossil* ivory is so cracked and foliated as to be useless for the purposes of art. Now, the climate of France in the Reindeer Age, though still frigid, had long ceased to be glacial; and, even though the men of that period had been accustomed to dig the earth—and they were not—the fossil ivory they might have found would have been unserviceable. Therefore, the mammoths, whose ivory they wrought, must have been contemporary with themselves. Of this conclusion we have a decisive proof in the plate of ivory discovered at the La Madelaine, in 1864, by

E. Lartet, De Verneuil, and Falconer. It will be seen to contain an engraved design of the mammoth, as his carcass is to this day found on the banks of the Lena. (*See* vol. i. of THE POPULAR SCIENCE MONTHLY, p. 215.)

The Troglodytes of the Reindeer Age had but rarely the opportunity of measuring strength with the mammoth. Their game was more commonly the aurochs, the horse, the ox; and doubtless it was in the pursuit of these great animals that they used their long spears tipped with flint. Still, nearly all their weapons were light, and mostly tipped with reindeer-horn. The bow became their principal weapon, in proportion as the animals they hunted grew more timid and wary. Their arrows were of two kinds: a small one, with pointed tip, without a barb, for small game and birds; and a large one, with two rows of barbs, for hunting the reindeer. The rest of their equipment consisted of light lances with blunt heads, darts with conical points, and long, sharp daggers, for close quarters. They had also a whistle to summon their companions in the chase; this was made of reindeer-bone.

That our Troglodytes followed fishing also is shown by the number of fish-bones found in their caves; but, strange to say, salmon was their only fish. At the present day salmon does not go up the Vézère, nor is it found in the Dordogne as far up as the mouth of the Vézère. There is every reason for believing that these ancient fishers did not use a line, for with a line the fisherman takes fish of every kind. If they employed only the harpoon, we can well understand why they could take only large fish, and why among these they should select the salmon, whose flesh they prized most. But did they fish from boats? We have no evidence bearing on this point; but the Vézère was so closely confined by steep banks, that the salmon might easily be harpooned from the shore. The harpoon used by our Troglodytes was a small dart of reindeer-horn, with barbs on one side only, and having a projection at its base, to fasten it to the line.

FIG. 2.

BONE HARPOON FROM TERRA DEL FUEGO.

On returning from the chase or from fishing, the Troglodytes got ready the feast in their cave. The carcasses of reindeer and the smaller game were brought in whole, but large-sized animals, the horse or the ox, being too heavy to carry away whole, were cut up on the spot, the head and legs being carried off, and the rest of the skeleton left behind. Hence, among the leavings found in the caves, we scarcely ever meet with any bones from the trunk of large mam-

mals, while every part of the skeleton of reindeer and smaller animals is to be found. The soil in the caverns, wherever it contains crushed bones, contains also an immense amount of charred wood. This mixture of bones and charcoal occurs so generally, so uniformly, that it is not easy to suppose that the Troglodytes lighted fires merely for the purpose of keeping themselves warm. They must have lighted fires daily at all seasons of the year, and hence it is likely that they cooked their food.

We are unable to say whether they got their fire from flint, or from wood by friction. They had no pottery, and could not boil their provisions over the fire. And yet they did not roast their meat either, for you will rarely find in their caves a calcined bone, or only such bones as were evidently burned by mere chance. They may have boiled their meats in wooden troughs, bringing the water to a boil by casting into it red-hot stones. But I think it more likely that they cooked their meat beneath the ashes, as is still the custom of many savage tribes.

A tid-bit for them was the brain of animals, or the marrow, as is evidenced by the fact that all the skulls are cracked and all the marrow-bones (and they only) broken. All savages have a special liking for marrow, and have a peculiar way of cracking the bones containing it. The chief is always the first to suck the marrow-bone. Our Troglodytes had little wedge-shaped pieces of flint, which they used as hatchets to break these bones. We find also in their caves an implement of reindeer-horn which was probably used for getting out the marrow, though archæologists are divided as to its purpose.

After a meal, the Troglodytes left the bones scattered about the floor. In a warm climate these remnants would have given out an insupportable stench; but in those early times the temperature was very low in France, and our Troglodytes were not paragons of cleanliness. To their uncleanly habits we are indebted for what we know about their food. Their chief staple was reindeer meat; but they also eat the flesh of the horse, the aurochs, several species of the ox, the chamois, the wild-goat, and even some carnivora. They used also fish, and, by means of the bow and arrow, they could take winged game. The caves contain the remains of birds of many different species. But, among all these bones, we find no human remains; and, hence, we know that our good Troglodytes were not cannibals. That supreme delight of the savage soul was all unknown to them—devouring a vanquished foeman. I record this with pleasure, albeit I attach no exceptional importance to the question of anthropophagy. In the eyes of the philosopher the crime is not in devouring, but in killing a human being. Judging from the style of weapons these Troglodytes employed, we should say that they were quiet folk, not given to war.

It has been supposed that they wore no clothing, as all the human figures portrayed by their artists are nude (Fig. 5). This, however,

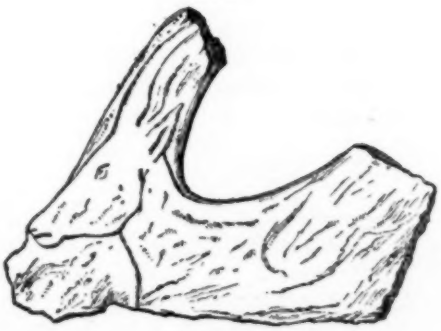
proves just nothing, because it proves too much. By parity of reasoning, the Greeks would have gone naked also. But we find in the caves all the necessary outfit of the (Troglodytic) tailor. There are needles of bone and of reindeer-horn, some of them being mere awls, but

FIG. 3.

DRAWING OF A FISH ON REINDEER-HORN.—(From La Madelaine.)

others having an eye to hold the thread. Some of these needles were very slender, and a needle-case, made of a bone from a bird, has been found, which might contain several of them. Lartet and Christy discovered the mode of manufacturing these needles. They give an engraving of the metacarpal of a horse, having a number of parallel cuttings lengthwise, all executed with a fine saw. The work was incomplete, but it is evident that here we have needles in process of manufacture.

FIG 4.



DRAWING OF AN IBEX.—(La Madelaine.)

The threads they used were doubtless of various kinds. But did they employ for this purpose vegetable fibres, or fine strips of hide? It is possible, or even probable, that they used both; but this at least is certain, that they made threads, or, at all events, cords, out of tendons. They removed carefully from the members of animals the long tendons, as is shown by the scratches on the bone at the point of insertion.

Needle-work implies clothing, not simply that primitive garment which consists of an animal's skin thrown over the shoulders, but a more complete vesture, made up of sundry skins. The quantity of needles and awls, and of scrapers for preparing skins for use, which we meet with in the caves, shows that the use of clothing was general among our Troglodytes.

But further, they wore ornaments, which perhaps served as marks of distinction. Thus, they had collars and bracelets made of pierced shells, hung on a string. Such shells have been found in most of the caves, and they occur in great numbers in the ancient place of sepulture at Cromagnon. Pieces of ivory, nicely fashioned, and bored with two holes, would appear to have been used to fasten the collar; and no doubt this is not the only outcropping of petty vanity of attire among our Troglodytes. Most savages have the habit of painting and tattooing their bodies; nor is the latter practice yet quite extinct among civilized races. In the caves are found several pieces of the bloodstone, showing signs of having been scraped. Hence we conclude that they prepared a red paint, and made constant use of it, probably in ornamenting their persons. Probably they also practised tattooing, for, when their artists picture, as they often do, the hand and forearm on a man on reindeer-horn, the lower part of the forearm bears a figure which may well be taken to represent a tattoo.

It has been already shown that our Troglodytes were not nomads; and, though individuals may have wandered abroad, the tribe never travelled to any distance away from their cave. Hence they must have acquired by barter objects coming from remote parts. The shells of their necklaces came from the Atlantic coast. They also used rock-crystal, which must have come from the Pyrenees, the Alps, or the mountains of Auvergne. Thus it is seen that the Troglodytes had relations with distant localities.

FIG. 5.

GROUP OF FIGURES—SNAKE OR EEL, MAN, AND TWO HORSE-HEADS.—(La Madelaine.)

If they had any religious belief, it has left no trace. They wore talismans or amulets, however, the incisor-teeth of wolves or reindeer, the ox, or the horse, with a hole in them, through which a string was passed. Similar talismans are still worn by savage huntsmen, to insure good luck in the pursuit of game. In Italy, down to the present day, a swine's tooth, set in silver, is attached to the swaddling-clothes of new-born infants, as a charm against the Evil Eye, and afterward serves as a *hochet*, when the child is cutting its teeth. If the wolves' and other animals' teeth we find in the caves were talismans, our Troglodytes had at least a superstition, and, though I am no theologian, I will say that it is difficult to decide just where superstition ends and religion begins.

In burying their dead, the contemporaries of our Troglodytes in other localities practiced certain funeral rites; and consoled themselves for their loss by partaking of a feast on a little platform in front of the sepulchral cave—a kind of solace not yet quite out of vogue. Only one place of burial has as yet been discovered in the neighborhood of the Vézère, namely, at Cromagnon. This is a mere nook beneath an overhanging rock; and flints and shell ornaments are found buried with the bodies. We find here no remnants of any stone enclosure.

Society among the Troglodytes had its hierarchical organization, with dignitaries of various grades. The three caves at Les Eyzies, Laugerie-Basse and La Madelaine contain the proofs of this assertion, in the shape of large pieces of reindeer horn, artistically fashioned, and commonly known as *bâtons de commandement*, commanders' truncheons. Several of these instruments have been found; they are all of one common type, their surface being highly ornamented with figures of animals, or of hunting-scenes, and are pierced with large

FIG. 6.

GROUP OF REINDEER.

round holes, from one to four in number. The purpose of these remarkable objects is matter of much dispute. It is true they much resemble the *pogamagan*, or tomahawk of the Mackenzie River Esquimaux, but the *pogamagan* is both longer, thicker, and far more solid, than the *bâtons de commandement*. The latter are too frail to be used for any mechanical purpose, and therefore they were most probably only insignia of rank, like the king's or the chief's sceptre, or the marshal's *bâton*. But there are so many of them, that we cannot regard them as regal insignia, and hence they may have been marks of hierarchical dignity, the holes denoting the rank, like the bars or stars on a mili-

tary officer's shoulder-straps. Thus the *bâton* without a hole would indicate the lowest grade of dignity, those with one or more holes indicating a higher and higher office, until we reach the fourth grade, indicated by four holes. The ornamentation commonly surrounds these holes, and this circumstance would seem to show that the *bâton* was made for some personage already clothed with official rank. But sometimes the hole is seen to have been pierced afterward, breaking up the lines and disfiguring the design. Thus we have a *bâton* bearing the figure of a horse, which is found broken in two by one of these perforations. The happy owner of the truncheon had gained promotion!

This ascending scale of degrees and ranks (which is the sure evidence of a numerous society) may, no doubt, have been of service in war, but it is very likely that its chief object was the organization of hunting expeditions, as the chase was the great employment of the tribe. In a climate colder than ours, the game would keep for a considerable time, in winter especially. Hence the caves held a more or less abundant supply of victuals, and a manager in chief was needed, to prevent waste and to make equitable distribution of the store. We find rods of reindeer-horn with a number of notches cut in regular series, which would appear to have been the managers' day-books. These rods, commonly known as *marques de chasse* (tallies of the chase), much resemble the *marques* used by bakers in small country villages in France at the present day. There has been also found in one of the caves a broad plate of ivory, having on its sharp edges a series of notches, and on its flat sides several rows of points, which would also appear to have been tallies.

Owing to this social organization and administration of affairs, Troglodytic society, though it embraced a numerous membership, lived comfortably enough. They had such an abundance of food that they could choose the best pieces, rejecting what was of inferior quality. Thus, they threw away the feet of animals, though these contain a considerable amount of nutritive substance. Hence we see that they had plenty to eat: and, as thus the whole time of the tribe need not have been taken up with the business of making provision for the body's wants, they could enjoy repose now and then—could enjoy leisure—and leisure, when improved intelligently, gives rise to the arts.

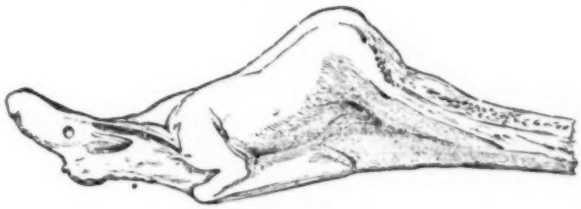
2. *The Arts among the Troglodytes.*

To Egypt no longer pertains the glory of having been the originator of the arts. It was with profound astonishment that the world learned, some years since, that long, long before the artists of Egypt, the men of the Age of the Reindeer had cultivated design, engraving, and even sculpture. At first, their works were greeted only with plaudits of admiration; but now, recovered as we are from this first impression,

we are forced to admit that in those ancient days, as in our own, there were not wanting bad artists; and, yet, amid a number of coarse designs, there are not a few which are truly worthy of note, and which betray an able hand, and an eye trained to observe Nature.

Designing undoubtedly preceded sculpture among the Troglodytes, and their figures in relief are much fewer in number and less perfect than their engraved sketches. These latter figures generally form the ornamentation of the *bâton de commandement*, or of the hafts of daggers; but sometimes they are found on stone slabs, or on plates of ivory or of reindeer-horn, which would appear to have been prepared

Fig. 7.



Handle of a Poniard.

simply to receive the engravings. Nearly all the designs represent objects in Nature, though some of them are simply ornamental lines, zigzags, curves, etc. Three small brank-ursines, engraved on a piece of reindeer-horn, would appear to represent a polypetal flower; but all the other figures represent animals. The reindeer occurs most frequently, the ox and the aurochs being more rare. These various animals are readily distinguishable in the engraved figures, their respective gait and motion being oftentimes reproduced with considerable exactness and elegance. Sometimes they are isolated, being represented, without any order, over the entire surface of some instrument; but, again, they are found grouped together, engaged in combat, etc. (Fig. 6). The engraving of the mammoth was found, in 1864, in the cave of La Madelaine. The head of the animal is given with remarkable exactitude. The Marquis de Vibraye has since discovered a *bâton de commandement*, with a mammoth's head sculptured on it. These two pieces are the only ones representing the mammoth which have come down to our time from the hands of the Troglodytic artists, but they suffice to show that the animal was not yet extinct.

Figures of fish are not rare, and they all, with one exception, represent the salmon. Élie Massénat found at Laugerie-Basse the shoulder-blade of an ox, bearing a rude sketch of a fishing-scene—a man casting a harpoon at some aquatic animal, a porpoise, apparently. This design has a special interest, as going to show that our Troglodytes fished with the harpoon.

In sketching the human figure (which they did but rarely), these

artists, who exhibited such skill in animal-sketching, do not show to much advantage. There is one *study* of a head, representing a grotesque profile. Two other figures represent the forearm and hand, four fingers being visible, and the thumb concealed. Add to these the fishing-scene and two hunting-scenes, and you have the complete list of figures relating to man in the Troglodytic Museum.

As I have already said, sculptures are of rarer occurrence here than engraved designs. Of the former we have not above half a dozen, all found at Laugerie-Basse. One of these, the property of the Marquis de Vibraye, represents a woman, and all the others represent animals, viz., a reindeer, head of the same animal, head of a mammoth (referred to already), and also one of some unknown animal. Finally, we have M. Massénat's latest discovery, known as the *Bœufs Jumeaux* (twin-oxen), which represents a pair of oxen, or, perhaps, of aurochsen.

These sculptures are sometimes incomplete, and always ill executed; but in the art of design the artists display surprising ability. They sketched the human figure badly, but they studied carefully the form and the gait of animals, which they sometimes reproduced with a degree of exactitude, elegance, and spirit, which evince the true artistic sentiment.

THE STUDY OF SOCIOLOGY.

By HERBERT SPENCER.

IX.—*The Bias of Patriotism.*

"OUR country, right or wrong," is a sentiment not unfrequently expressed on the other side of the Atlantic; and, if I remember rightly, an equivalent sentiment was some years ago uttered in our own House of Commons, by one who rejoices, or at least who once rejoiced, in the title of philosophical radical.

Whoever entertains such a sentiment has not that equilibrium of feeling required for dealing scientifically with social phenomena. To see how things stand, apart from personal and national interests, is essential before there can be reached those balanced judgments respecting the course of human affairs in general, which constitute Sociology. To be convinced of this, it needs but to take a case remote from our own. Ask how the members of an aboriginal tribe regard that tide of civilization which sweeps them away. Ask what the North-American Indians said about the spread of the white man over their territories, or what the ancient Britons thought of the invasions which dispossessed them of England; and it becomes clear that events which, looked at from an un-national point of view, were steps toward

a higher life, seemed from a national point of view entirely evil. Admitting the truth so easily perceived in these cases, we must admit that only in proportion as we emancipate ourselves from the bias of patriotism, and consider our own society as one among many, having their histories and their futures, and some of them, perhaps, having better claims than we have to the inheritance of the earth—only in proportion as we do this, shall we recognize those sociological truths which have nothing to do with particular nations or particular races.

So to emancipate ourselves is extremely difficult. It is with patriotism as we lately saw it to be with the sentiment that causes political subordination: the very existence of a society implies predominance of it. The two sentiments join in producing that social cohesion without which there cannot be coöperation and organization. A nationality is made possible only by the feeling which the units have for the whole they form. Indeed, we may say that the feeling has been gradually increased by the continual destroying of types of men whose attachments to their societies were relatively small; and who were, therefore, incapable of making adequate sacrifices on behalf of their societies. Here, again, we are reminded that the citizen, by his incorporation in a body politic, is in a great degree coerced into such sentiments and beliefs as further its preservation: unless this is the average result, the body politic will not be preserved. Hence another obstacle in the way of Social Science. We have to allow for the aberrations of judgment caused by the sentiment of patriotism.

Patriotism is nationally that which egoism is individually—has, in fact, the same root; and along with kindred benefits brings kindred evils. Estimation of one's society is a reflex of self-estimation; and assertion of one's society's claims is an indirect assertion of one's own claims as a part of it. The pride a citizen feels in a national achievement, is the pride belonging to a nation capable of that achievement: the belonging to such a nation having the tacit implication that in in himself there exists the superiority of nature displayed. And the anger aroused in him by an aggression on his nation is an anger against something which threatens to injure him by injuring his nation.

As, lately, we saw that a duly-adjusted egoism is essential; so now, we may see that a duly-adjusted patriotism is essential. Self-regard in excess produces two classes of evils: by prompting undue assertion of personal claims it breeds aggression and antagonism; and by creating undue estimation of personal powers it excites futile efforts that end in catastrophes. Deficient self-regard produces two opposite classes of evils: by not asserting personal claims, it invites aggression, so fostering selfishness in others; and by not adequately valuing personal powers it causes a falling short of attainable benefits. Similarly with patriotism. From too much, there result national aggressiveness and

national vanity. Along with too little, there goes an insufficient tendency to maintain national claims leading to trespasses by other nations; and there goes an undervaluing of national capacity and institutions, which is discouraging to effort and progress.

The effects of patriotic feeling which here concern us, are those it works on belief rather than those it works on conduct. As disproportionate egoism, by distorting a man's conceptions of self and of others, vitiates his conclusions respecting human nature and human actions; so disproportionate patriotism, by distorting his conceptions of his own society and of other societies, vitiates the conclusions respecting the natures and actions of societies. And from the opposite extremes there result opposite distortions: which, however, are comparatively infrequent and much less detrimental.

Here we come upon one of the many ways in which the corporate conscience proves itself less developed than the individual conscience. For, while excess of egoism is everywhere regarded as a fault, excess of patriotism is nowhere regarded as a fault. A man who recognizes his own errors of conduct and his own deficiencies of faculty, shows a trait of character considered praiseworthy; but to admit that our doings toward other nations have been wrong is reprobated as unpatriotic. Defending the acts of another people with whom we have a difference, seems to most citizens something like treason; and they use offensive comparisons concerning birds and their nests, by way of condemning those who ascribe misconduct to our own people rather than to the people with whom we are at variance. Not only do they exhibit the unchecked sway of this reflex egoism which constitutes patriotism—not only are they unconscious that there is any thing blameworthy in giving the rein to this feeling; but they think the blameworthiness is in those who restrain it, and try to see what may be said on both sides. Judge, then, how seriously the patriotic bias, thus perverting our judgments about international actions, necessarily perverts our judgments about the characters of other societies, and so vitiates sociological conclusions.

We have to guard ourselves against this bias. To this end let us take some examples of the errors attributable to it.

What mistaken estimates of other races may result from overestimation of one's own race, will be most vividly shown by a case in which we are ourselves valued at a very low rate by a race we hold to be far inferior to us. Here is an instance supplied by a tribe of negroes:

"They amused themselves by remarking on the sly, 'The white man is an old ape.' The African will say of the European, 'He looks like folks' (men), and the answer will often be, 'No, he don't.' . . . . While the Caucasian doubts the humanity of the Hamite, the latter repays the compliment in kind."[1]

[1] Burton's "Abeokuta," vol. ii., pp. 43, 44.

Does any one think this instance so far out of the ordinary track of error, as to have no instruction for us? To see the contrary he has but to look at the caricatures of Frenchmen that were common a generation ago, or to remember the popular statement then current respecting the relative strengths of French and English. Such reminders will convince him that the reflex self-esteem we call patriotism, has had, among ourselves, perverting effects sufficiently striking. And even now there are kindred opinions which the facts, when examined, do not bear out: instance the opinion respecting personal beauty. That the bias thus causing misjudgments in cases where it is checked by direct perception, causes greater misjudgments where direct perception cannot check it, needs no proof. How great are the mistakes it generates, all histories of international struggles show us, both by the contradictory estimates the two sides form of their respective leaders and by the contradictory estimates the two sides form of their deeds. Take an example:

"Of the character in which Wallace first became formidable, the accounts in literature are distractingly conflicting. With the chroniclers of his own country, who write after the War of Independence, he is raised to the highest pinnacle of magnanimity and heroism. To the English contemporary chroniclers he is a pestilent ruffian; a disturber of the peace of society; an outrager of all laws and social duties; finally, a robber—the head of one of many bands of robbers and marauders then infesting Scotland."[1]

That, along with such opposite distortions of belief about conspicuous persons, there go opposite distortions of belief about the conduct of the peoples they belong to, the accounts of every war demonstrate. Like the one-sidedness shown within our own society by the remembrance among Protestants of Roman Catholic cruelties only, and the remembrance among Roman Catholics of Protestant cruelties only, is the one-sidedness shown in the traditions preserved by each nation concerning the barbarities of nations it has fought with. As in old times the Normans, savage themselves, were shocked at the vindictiveness of the English when driven to bay; so in recent times the French have enlarged on the atrocities committed by Spanish guerrillas, and the Russians on the atrocities the Circassians perpetrated. In this conflict between the views of those who commit savage acts, and the views of those on whom they are committed, we clearly perceive the bias of patriotism where both sides are aliens; but we fail to perceive it where we are ourselves concerned as actors. Every one old enough remembers the reprobation vented here when the French in Algiers dealt so cruelly with Arabs who refused to submit—lighting fires at the mouths of caves in which they had taken refuge; but we do not see a like barbarity in deeds of our own in India, such as the executing a group of rebel sepoys by fusillade, and then setting fire to the heap of them because they were not

[1] Burton's "History of Scotland," vol. ii., pp. 281, 282.

all dead,[1] or in the wholesale shootings and burnings of houses, after the suppression of the Jamaica insurrection. Listen to what is said at home about such deeds in our own colonies, and you find that habitually they are held to have been justified by the necessities of the case. Listen to what is said about such deeds when other nations are guilty of them, and you find the same persons indignantly declare that no alleged necessities could form a justification. Nay, the bias produces perversions of judgment even more extreme. Feelings and deeds we laud as virtuous when they are not in antagonism with our own interests and power, we think vicious feelings and deeds when our own interests and power are endangered by them. Equally in the mythical story of Tell, and in any account not mythical, we read with glowing admiration of the successful rising of an oppressed race; but admiration is changed into indignation if the race is one held down by ourselves. We can see nothing save crime in the endeavor of the Hindoos to throw off our yoke; and we recognize no excuse for the efforts of the Irish to establish their independent nationality. We entirely ignore the fact that the motives are, in all such cases, the same, and, in the abstract, are to be judged apart from results.

A bias which thus vitiates even the perceptions of physical appearances, which so greatly distorts the beliefs about conspicuous antagonists and their deeds, which leads us to reprobate in other nations severities and cruelties that we applaud when committed by our own agents, and which makes us regard acts of intrinsically the same kind as wrong or right according as they are or are not directed against ourselves, is a bias which inevitably perverts our sociological ideas. The institutions of a despised people cannot be judged with fairness; and if, as often happens, the contempt is unwarranted, or but partially warranted, such value as their institutions have will certainly be underestimated. When antagonism has bred hatred toward another nation, and has, consequently, bred a desire to justify the hatred by ascribing a hateful character to members of that nation, it inevitably happens that the political arrangements under which they live, the religion they profess, and the habits peculiar to them, become associated in thought with this hateful character—become themselves hateful, and cannot therefore have their natures studied with the calmness required by science.

An example will make this clear. The reflex egoism we name patriotism, causing, among other things, a high valuation of the religious creed nationally professed, makes us overrate the effects this creed has produced, and makes us underrate the effects produced by other creeds, and by influences of other orders. The notions respecting savage and civilized races, in which we are brought up, show this.

[1] I make this statement on the authority of a letter read to me at the time by an Indian officer, written by a brother officer in India.

The word savage, originally meaning wild or uncultivated, has come to mean cruel and blood-thirsty, because of the representations habitually made that wild or uncultivated tribes of men are cruel and blood-thirsty. And ferocity having come to be thought of as a constant attribute of uncivilized races, which are also distinguished by not having our religion, it is tacitly assumed that the absence of our religion is the cause of this ferocity. But if, struggling successfully against the bias of patriotism, we correct the evidence which that bias has garbled, we find ourselves obliged to receive this assumption with great qualifications.

When, for instance, we read Cook's account of the Tahitians, as first visited by him, we are surprised to meet with some traits among them, higher than those of their civilized visitors. Though some pilfering was committed by them, it was not so serious as that of which the sailors were guilty in stealing the iron bolts out of their own ship to pay the native women. And when, after Cook had enacted a penalty for theft, the natives complained of one of his own crew—when this sailor, convicted of the offence he was charged with, was condemned to be whipped, the natives tried to get him off, and, failing to do this, shed tears on seeing preparations for the punishment. If, again, we compare critically the accounts of Cook's death, we see clearly enough that the Sandwich-Islanders behaved amicably until they had been ill-used, and had reason to fear further ill-usage. The experiences of many other travellers similarly show us that friendly conduct on the part of uncivilized races, when first visited, is very general; and that their subsequent unfriendly conduct, when it occurs, is nothing but retaliation for injuries received from the civilized. Such a fact as that the natives of Queen Charlotte's Island did not attack Captain Carteret's party till after they had received just cause of offence,[1] may be taken as typical of the histories of transactions between wild races and cultivated races. When we inquire into the case of the missionary Williams, "the Martyr of Erromanga," we discover that his murder, dilated upon as proving the wickedness of unreclaimed natures, was a revenge for injuries previously suffered from wicked Europeans. Here are a few testimonies respecting the relative behaviors of civilized and uncivilized:

"After we had killed a man at the Marquesas, grievously wounded one at Easter Island, hooked a third with a boat-hook at Tonga-tabu, wounded one at Namocka, another at Mallicollo, and killed another at Tauna; the several inhabitants behaved in a civil and harmless manner to us, though they might have taken ample revenge by cutting off our straggling parties."[2]

"Excepting at Cafta, where I was for a time supposed to come with hostile intent, I was treated inhospitably by no one during all my travels, excepting by Europeans, who had nothing against me but my apparent poverty."[3]

[1] Hawkesworth's "Voyages," vol i., p. 573.
[2] Parkyns's "Abyssinia," vol. ii., p. 431.
[3] Forster's "Observations," etc., p. 406.

"In February, 1812, the people of Winnebah (Gold Coast) seized their commandant, Mr. Meredith," and so maltreated him that he died. The town and fort were destroyed by the English. "For many years afterward, English vessels passing Winnebah were in the habit of pouring a broadside into the town, to inspire the natives with an idea of the severe vengeance which would be exacted for the spilling of European blood." [1]

Or, instead of these separate testimonies, take the opinion of one who collected many testimonies. Referring to the kind treatment experienced by Encisco from the natives of Cartagena (on the coast of New Granada), who a few years before had been cruelly treated by the Spaniards, Washington Irving says:

"When we recall the bloody and indiscriminate vengeance wreaked upon this people by Ojida and his followers for their justifiable resistance of invasion, and compare it with their placable and considerate spirit when an opportunity for revenge presented itself, we confess we feel a momentary doubt whether the arbitrary appellation of savage is always applied to the right party." [2]

The reasonableness of this doubt will scarcely be questioned, after reading of the diabolical cruelties committed by the invading Europeans in America; as, for instance, in St. Domingo, where the French made the natives kneel in rows along the edge of a deep trench and shot them batch after batch, until the trench was full, or, as an easier method, tied numbers of them together, took them out to sea, and tumbled them overboard; and where the Spaniards treated so horribly the enslaved natives, that these killed themselves wholesale: the various modes of suicide being shown in Spanish drawings.

Does the Englishman say that these, and hosts of like demoniacal misdeeds, are the misdeeds of other civilized races in other times; and that they are attributable to that corrupted religion which he repudiates? If so, he may be reminded that sundry of the above facts are facts against ourselves. He may be reminded, too, that the purer religion he professes has not prevented a kindred treatment of the North American Indians by our own race. And he may be put to the blush by accounts of barbarities going on in our own colonies at the present time. Without detailing these, however, it will suffice to recall the most recent notorious case—that of the kidnappings and murders in the South Seas. Here we find repeated the typical relations; betrayals of many natives and merciless sacrifices of their lives; eventual retaliation by the natives to a small extent; a consequent charge against the natives of atrocious murder; and then a wholesale massacre of them, innocent and guilty together.

See, then, how the bias of patriotism indirectly produces erroneous views of the effects of an institution. Blinded by national self-love to the badness of our conduct toward inferior races, while remem-

[1] Cruickshank, "Eighteen Years on the Gold Coast of Africa," vol. i., p. 100.
[2] "Companions of Columbus," p. 115.

bering what there is of good in our conduct; forgetting how well these inferior races have usually behaved to us, and remembering only their misbehavior, which we refrain from tracing to its cause in our own transgressions; we overvalue our own natures as compared with theirs. And then, looking at the two as respectively Christian and heathen, we overrate the good done by Christian institutions (which has doubtless been great), and we underrate the advance that has been made without them. We do this habitually in other cases. As, for instance, when we ignore evidence furnished by the history of Buddhism; respecting the founder of which Canon Liddon lately told his hearers that "it might be impossible for honest Christians to think over the career of this heathen prince without some keen feelings of humiliation and shame."[1] And ignoring all such evidence, we get one-sided impressions. Thus our sociological conceptions are distorted —do not correspond with the facts; that is, are unscientific.

To illustrate some among the many effects wrought by the bias of patriotism in other nations, and to show how mischievous are the beliefs it fosters, I may here cite evidence furnished by France and by Germany.

Contemplate that undue self-estimation which the French have shown us. Observe what has resulted from that exalted idea of French power which the writings of M. Thiers did so much to maintain and increase. When we remember how, by causing undervaluation of other nations, it led to a disregard of their ideas and an ignorance of their doings—when we remember how, in the late war, the French, confident of victory, had maps of German territory but not of their own, and suffered catastrophes from this and other kinds of unpreparedness; we see what fatal evils this reflex self-esteem may produce when in excess. So, too, on studying the way in which it has influenced French thought in other directions. Looking at Crimean battle-pieces, in which French soldiers are shown to have achieved every thing—looking at a picture like Ingres's "Crowning of Homer," and noting French poets conspicuous in the foreground, while the figure of Shakespeare in one corner is half in and half out of the picture—reading the names of great men of all nations inscribed on the string-course running round the *Palais de l'Industrie*, and finding many unfamiliar French names, while (strange oversight, as we must suppose) the name of Newton is conspicuous by its absence; we see exemplified a national sentiment which, generating the belief that things not French deserve little attention, acts injuriously on French thought and French progress. From Victor Hugo's magniloquent description of France as the savior of nations, down to the declamations of those who urged that were Paris destroyed the light of civilization would be extinguished, we see, throughout, the conviction that France is the great teacher, and by implication needs not to be a learner. The diffusion

[1] *Times*, January 22, 1873.

of French ideas is an essential thing for other nations; while the absorption of ideas from other nations is not an essential thing for France: the truth being, rather, that French ideas, more than most other ideas, stand in need of foreign influence to qualify the undue definiteness and dogmatic character they habitually display. That such a tone of feeling, and the mode of thinking appropriate to it, should vitiate sociological speculation, is a matter of course. If there needs proof, we have a conspicuous one in the writings of M. Comte; where excessive self-estimation under its direct form, and under that reflex form constituting patriotism, has led to astounding sociological misconceptions. If we contemplate that scheme of Positivist reorganization and federation in which France was, of course, to be the leader —if we note the fact that M. Comte expected the transformation he so rigorously formulated to take place during the life of his own generation; and if, then, we remember what has since happened, and consider what are the probabilities of the future, we shall not fail to see how great are the perversions of sociological belief this bias may produce.

How national self-esteem, exalted by success in war, warps sociological opinion, is again shown of late in Germany. As a German professor writes to me, "there is, alas, no want of signs" that the "happy contrast to French self-sufficiency" which Germany heretofore displayed, is disappearing "since the glory of the late victories." The German liberals, he says, "overflow with talk of Germanism, German unity, the German nation, the German Empire, the German army and the German navy, the German Church, and German science. . . . They ridicule Frenchmen, and what animates them is, after all, the French spirit translated into German." And, then, to illustrate the injurious reaction on German thought, and on the estimates of foreign nations and their doings, he describes his discussion with an esteemed German professor of philosophy, against whom he was contending that the psychical and ethical sciences would gain in progress and influence by international communion, like that among the physico-mathematical sciences. He, "to my astonishment, declared that, even if such a union were possible, he did not think it desirable, as it would interfere too much with the peculiarity of German thought. . . . Second to Germany," he said, "it was Italy, which, in the immediate future, was most likely to promote philosophy. . . . It appeared that what made him prefer the Italians . . . . was nothing else than his having observed that in Italy they were acquainted with every philosophical treatise published in Germany, however unimportant." And, thus, adds my correspondent, "the finest German characteristics are disappearing in an exaggerated Teutonomania." One other truth his comments on German feeling make manifest. There is indirectly an antagonism between the sentiment of nationality and the sentiment of individuality; the result of which is that exaltation of the one involves

depression of the other, and a decreased regard for the institutions it originates. Speaking of the "so-called National Liberals," he says: "A friend of mine was lately present at a discussion, in the course of which a professor of philosophy, of the University of ——, was very eloquently, and with perfect seriousness, contending that only one thing was now wanting to complete our German institutions—a national costume. Other people, who, no doubt, are fully aware of the ridiculousness of such things, are, nevertheless, guilty of an equally absurd, and even more intolerable encroachment on individual liberty; since, by proposing to establish a national church, they aim at constraining the adherents of the various religious bodies into a spiritual uniform. Indeed, I should hardly have thought it possible that a German government could encourage such monstrous propositions, if they had not been expounded to me at the Ministry of Public Worship."

Saying no more about patriotism and its perverting effects on sociological judgments, which are indeed so conspicuous all through history as scarcely to need pointing out, let me devote the remaining space to the perverting effects of the opposite feeling—anti-patriotism. Though the distortions of opinion hence resulting are less serious, still they have to be guarded against.

In England the bias of anti-patriotism does not diminish in a marked way the admiration we have for our political institutions, but only here and there prompts the wish for a strong government, to secure the envied benefits ascribed to strong governments abroad. Nor does it appreciably modify the general attachment to our religious institutions, but, only in a few who dislike independence, shows itself in advocacy of an authoritative ecclesiastical system fitted to remedy what they lament as a chaos of religious beliefs. In other directions, however, it is displayed so frequently and conspicuously as to affect public opinion in an injurious way. In respect to the higher orders of intellectual achievement, undervaluation of ourselves has become a fashion, and the errors it fosters react detrimentally on the estimates we make of our social *régime*, and on our sociological beliefs in general.

What is the origin of this undue self-depreciation? In some cases, no doubt, it results from disgust at the jaunty self-satisfaction caused by the bias of patriotism, when excessive. In other cases, it grows out of affectation: to speak slightingly of what is English seems to imply wide knowledge of what is foreign, and brings a reputation for culture. In the remaining cases, it is due to ignorance. Passing over such of these self-depreciatory estimates of our powers and achievements as have partial justifications, I will limit myself to one which has no justification. Among the classes here indicated, it is the custom to speak disparagingly of the part we play in discovery and invention. There is an assertion occasionally to be met with in public journals, that the French invent and we improve. Not long since, it was confessed by

the Attorney-General that the English are not a scientific nation. Recently the *Times*, commenting on a speech of Mr. Gladstone, said: "There is truth, however, in the assertion that we are backward in appreciating and pursuing abstract knowledge."[1] Such statements exhibit the bias of anti-patriotism creating a belief that is wholly indefensible. As we shall presently see, they are flatly contradicted by facts, and can be accounted for only by supposing that those who make them have had a culture exclusively literary.

A convenient way of dealing with this bias of anti-patriotism will be to take an individual example of it. More than any other, Mr. Matthew Arnold has of late made himself an exponent of the feeling. His motive cannot be too highly respected, and for much that he has said in reproof of the vainglorious, entire approval may rightly be felt. Many grave defects in our social state, many absurdities in our modes of action, many errors in our estimates of ourselves, are to be pointed out, and dwelt upon, and great good is done by a writer who efficiently executes the task of making us feel our shortcomings. In his condemnation of the ascetic view of life which still prevails here, one may entirely agree. The undue estimation of material prosperity common with us is a fault justly insisted on by him. And the overweening confidence so often shown in a divine favor gained by our greater national piety, is also an attitude of mind deservedly to be reprobated. But, by reaction, Mr. Arnold is, I think carried too far in the direction of anti-patriotism, and weakens the effect of his criticism by generating a re-reaction. Let us glance at some of his views:

The mode of procedure generally followed by Mr. Arnold is not that of judicially balancing the evidence, but that of meeting the expression of self-satisfied patriotism by some few facts calculated to cause dissatisfaction: not considering what is their quantitative value. To reprove a piece of national self-laudation uttered by Mr. Roebuck, he comments on the murder of an illegitimate child by its mother, reported in the same paper. Now this would be effective if infanticide were peculiar to England, or if he could show a larger proportion of infanticide here than elsewhere; but his criticism is at once cancelled on calling to mind the developed system of baby-farming round Paris, and the extensive getting-rid of infants to which it is instrumental. By following Mr. Arnold's method, it would be easy to dispose of his conclusions. Suppose, for instance, that I were to set down the many murders committed in England by foreigners, within our own memories, including those by Courvoisier, by Mrs. Manning, by Barthélemi, near Fitzroy Square, by a Frenchman, in Foley Place (about 1854–'57), that by Müller, that by Kohl, in the Essex marshes, that by Lani, in a brothel near the Haymarket, that by Marguérite Diblanc, the tragedy of the two young Germans (Mai and Nagel), at Chelsea, ending with

[1] *Times*, December 23, 1872.

the recent one in Great Coram Street—suppose I were to compare the ratio borne by this number of murderers to the number of foreigners in England with the answering ratio among our own people; and suppose I were to take this as a test of the Continental culture Mr. Arnold so much admires. Probably, he would not think the test quite relevant, and yet it would be quite as relevant as that he uses—perhaps somewhat more relevant. Suppose, again, that, by way of criticism on German administration, I were to dwell on the catastrophe at Berlin, where, during the celebration of victory, fourteen sight-seers were killed, and some hundreds injured; or, suppose I were further to judge it by the disclosures of the leading Berlin physician, Virchow, who shows that one out of every three children born in Berlin dies the first year, and whose statistics prove the general mortality to be increasing so rapidly that, while "in 1854 the death-rate was 1,000, in 1851–'64 it rose to 1,164, and in 1864–'68 to 1,817"[1]—suppose, I say, that I took these facts as proof of failure in the social system Mr. Arnold would have us copy. Possibly he would not be much shaken, though it seems to me that this evidence would be more to the point than a case of infanticide among ourselves. Further, suppose I were to test French administration by the statistics of mortality in the Crimea, as given at the late meeting of the French Association for the Advancement of Science, by M. Le Fort, who pointed out that—

> "During those six months of winter, 1855–'56, when hostilities were almost suspended, the English having only 165 wounded in six months, and the French 323, the English army, thanks to the precautions taken, had but few men in the hospitals and lost only 606, while the French army witnessed the outbreak of the typhus in its midst, though it might have been avoided, and lost, from disease alone, 21,190 men."

and who further, respecting the relative mortalities from operations, said that—

> "In the Crimea the English and French armies were exposed to the same wants, to the same atmospheric changes, and yet what a difference of mortality in surgical cases! The English lost 24 per cent. of their cases of arm-amputations, while we lost double that number, or 55 per cent. The same is to be said of amputations of the leg: 35 per cent. against 71."

—suppose, I say, that I were thus to deal with the notion that "they manage these things better in France." Mr. Arnold would, very likely, not abandon his belief. And yet this contrast would certainly be as damaging as the fact about the girl Wragg, to which he more than once refers so emphatically. Surely it is manifest enough that, by selecting the evidence, any society may be relatively blackened, and any other society relatively whitened.

From Mr. Arnold's method let us turn to some of his specific statements: taking first the statement that the English are deficient in ideas.

[1] *Lancet*, December 28, 1872.

He says: "There is the world of ideas, and there is the world of practice; the French are often for suppressing the one, and the English the other."[1] Admitting the success of the English in action, Mr. Arnold thinks that it goes along with want of faith in speculative conclusions. But by putting ideas and practice in this antithesis, he implies his acceptance of the notion that effectual practice does not depend on superiority of ideas. This is an erroneous notion. Methods that answer are preceded by thoughts that are true. A successful enterprise presupposes an imagination of all the factors, and conditions, and results; which differs from the imagination leading to an unsuccessful enterprise in this, that what will happen is clearly and completely foreseen, instead of being foreseen vaguely and incompletely: there is greater ideality. Every scheme is an idea; every scheme, more or less new, implies an idea more or less original; every scheme proceeded with, implies an idea vivid enough to prompt action; and every scheme which succeeds, implies an idea so accurate and exhaustive that the results correspond with it. When an English company accommodates Amsterdam with water—an element the Dutch are very familiar with, and in the management of which they, centuries ago, gave us lessons—must we not say that, by leaving us to supply their chief city, they show a want of confidence in results ideally seen? Is it replied that the Dutch are not an ideal people? Then take the Italians. How happens it that such a pressing need as the draining of Naples has never suggested to Italian rulers or Italian people the taking of measures to achieve it; and how happens it that the idea of draining Naples, instead of emanating from French or Germans, supposed by Mr. Arnold to have more faith in ideas, emanates from a company of Englishmen, who are now proposing to do the work without cost to the municipality?[2] Or what shall we infer as to relative faith in ideas, on learning that even within their respective territories the French and Germans wait for us to undertake new things for them? When we find that Toulouse and Bordeaux were lighted with gas by an English company, must we not infer lack of ideas in the people of those places? When we find that a body of Englishmen, the Rhone Hydraulic Company, seeing that at Bellegarde there are rapids having a fall of forty feet, made a tunnel carrying a fourth of the river, and so got 10,000 horse-power, which they are selling to manufacturers; and when we ask why this source of wealth was not utilized by the French themselves; must we not say that it was because the idea did not occur to them, or because it was not vivid and complete enough to prompt the enterprise? And when, on going north, we discover that not only in Belgium and Holland are the chief towns, Brussels, Antwerp, Lille, Ghent, Rotterdam, Amsterdam, Haarlem, etc., lighted by our Continental Gas Association, but that this combination of Englishmen lights many towns in Germany also—Hanover, Aix-la-Chapelle, Stolberg,

[1] "Essays in Criticism," p. 12.

[2] *Times*, January 22, 1873.

Cologne, Frankfort, Vienna, nay, that even the headquarters of *geist*, Berlin itself, had to wait for light until this Company supplied it, must we not say that more faith in ideas was shown by English than by Germans? Germans have plenty of energy, are not without desire to make money, and knew that gas was used in England; and, if neither they nor their Governments undertook the work, we must infer that the benefits and means were inadequately conceived. English enterprises have often been led by ideas that looked wholly unpractical; as when the first English steamer astonished the people of Bonn by making its appearance there, so initiating the Rhine steam-navigation; or as when the first English steamer started across the Atlantic. Instead of our practice being unideal, the ideas which guide it sometimes verge on the romantic. Fishing-up a cable from the bottom of an ocean three miles deep, was an idea seemingly more fitted for the "The Arabian Nights" than for actual life; yet success proved how truly those who conducted the operation had put together their ideas in correspondence with the facts—the true test of vivid imagination.

To show the groundlessness of the notion that new ideas are not evolved and appreciated as much in England as elsewhere, I am tempted here to enumerate our modern inventions of all orders; from those directly aiming at material results, such as Trevethick's first locomotive, up to the calculating-machines of Babbage and the logic-machine of Jevons, quite remote from practice in their objects. But, merely asserting that those who go through the list will find that neither in number nor in importance do they yield to those of any nation during the same period, I refrain from details. Partly I do this because the space required for specifying them would be too great; and partly because inventions, mostly having immediate bearings on practice, would perhaps not be thought by Mr. Arnold to prove fertility of idea: though, considering that each machine is a theory before it becomes a concrete fact, this would be a position difficult to defend. To avoid all possible objection, I will limit myself to scientific discovery, from which the element of practice is excluded; and, to meet the impression that scientific discovery in recent days has not maintained its former pace, I will name only our achievements since 1800.

Taking first the Abstract Sciences, let us ask what has been done in Logic. We have the brief but pregnant statement of inductive methods by Sir John Herschel, leading to the definite systematization of them by Mr. Mill; and we have, in the work of Prof. Bain, elaborately-illustrated applications of logical methods to science and to the business of life. Deductive Logic, too, has been developed by a further conception. The doctrine of the quantification of the predicate, set forth in 1827 by Mr. George Bentham, and again set forth under a numerical form by Prof. De Morgan, is a doctrine supplementary to that of Aristotle; and the recognition of it has made it easier than

before to see that Deductive Logic is a science of the relations implied by the inclusions, exclusions, and overlappings of classes.[1] Even were this all, the instalment of progress would be large for a single generation. But it is by no means all. In the work by Prof. Boole, "Investigation of the Laws of Thought," the application to Logic of methods like those of Mathematics, constitutes another step far greater in originality and in importance than any taken since Aristotle. So that, strangely enough, the assertion quoted above, that "we are backward in appreciating and pursuing abstract knowledge," and this complaint of Mr. Arnold that our life is wanting in ideas, come at a time when we have lately done more to advance the most abstract and purely-ideal science than has been done anywhere else, or during any past period!

In the other division of Abstract Science—Mathematics—a recent revival of activity has brought results sufficiently striking. Though, during a long period, the bias of patriotism and an undue reverence for that form of the higher calculus which Newton initiated, greatly retarded us; yet since the recommencement of progress, some five-and-twenty years ago, Englishmen have again come to the front. Sir W. R. Hamilton's method of Quaternions is a new instrument of research; and, whether or not as valuable as some think, undoubtedly adds a large region to the world of known mathematical truth. And then, more important still, there are the achievements of Cayley and Sylvester in the development of the higher algebra. From competent and unbiassed judges I learn that the Theory of Invariants, and the methods of investigation which have grown out of it, constitute a step in mathematical progress larger than any made since the Differential Calculus. Thus, without enumerating the minor achievements of others, there is ample proof that abstract science, of this order also, is flourishing among us in great vigor.

Nor, on passing to the Abstract-Concrete sciences, do we find any better ground for this belief entertained by Mr. Arnold and others. Though Huyghens conceived of light as constituted of undulations, yet he was wrong in conceiving the undulations as allied in form to those of sound; and it remained for Dr. Young to establish the true theory. Respecting the principle of interference of the rays of light propounded by Young, Sir John Herschel says: "Regarded as a physical law [it] has hardly its equal for beauty, simplicity, and extent of application, in the whole circle of science;" and of Young's all-impor-

[1] Most readers of logic will, I suppose, be surprised on missing from the above sentence the name of Sir W. Hamilton. They will not be more surprised than I was myself on recently learning that Mr. George Bentham's work, "Outline of a New System of Logic," was published six years before the earliest of Sir W. Hamilton's logical writings, and that Sir W. Hamilton reviewed it. The case adds another to the multitudinous ones in which the world credits the wrong man; and persists in crediting him in defiance of evidence.

tant discovery that the luminiferous undulations are lateral not longitudinal, he says that it showed "a sagacity which would have done honor to Newton himself." Just naming the discovery of latent heat by Black, the discrimination by Wollaston of quantity and intensity in electricity, and the disclosure of electrolysis by Nicholson and Carlisle (all of them cardinal discoveries) and passing over minor contributions to physical science, we come to the great contributions of Faraday—magneto-electricity, the quantitative law of electrolysis, the magnetization of light, and dia-magnetism: not mentioning others of much significance. Next there is the great truth which men still living have finally established—the correlation and equivalence of the physical forces. In the establishment of this truth Englishmen have had a large share—some think the larger share. Remembering that in England the conception of heat as a mode of motion dates from Bacon, by whom it is expressed with an insight that is marvellous considering the knowledge of his time — remembering, too, that "Locke stated a similar view with singular felicity;" we come, among Englishmen of the present century, first to Davy, whose experiments and arguments so conclusively supported those of Rumford; then to the view of Roget and the postulate on which Faraday habitually reasoned, that all force arises only as other force is expended; then to the essay of Grove, in which the origin of the various forms of force out of one another was abundantly exemplified; and finally to the investigations by which Joule established the quantitative relations between heat and motion. Without dwelling on the important deductions from this great truth made by Sir W. Thomson, Rankine, Tyndall, and others, I will merely draw attention to its highly-abstract nature as again showing the baselessness of the above-quoted notion.

Equally conclusive is the evidence when we pass to Chemistry. The cardinal value of the step made by Dalton, in 1808, when the *aperçu* of Higgins was reduced by him to a scientific form, will be seen on glancing into Wurtz's "Introduction to Chemical Philosophy," and observing how the atomic theory underlies all subsequent chemical discovery. Nor, in more recent days, has the development of this theory fallen unduly into foreign hands. Prof. Williamson, by reconciling the theory of radicals with the theory of types, and by introducing the hypothesis of condensed molecular types, has taken a leading part in founding the modern views of chemical combinations. We come next to the cardinal conception of atomicity. In 1851, Prof. Frankland initiated the classification of the elements by their atomicities: his important generalization being now avowedly accepted in Germany by those who originally disputed it; as by Kolbe in his "Moden der Modernen Chemie." On turning from the more general chemical truths to the more special chemical truths, a like history meets us. Davy's discovery of the metallic bases of the alkalies and earths was an all-important step. Passing over many other achieve-

ments in special chemistry, I may single out, for their significance, the discoveries of Andrews, Tait, and especially of Brodie, respecting the constitution of ozone as an allotropic form of oxygen; and may join with these Brodie's discoveries respecting the allotropic forms of carbon, as throwing so much light on allotropy at large. And then we come to the all-important discoveries, general and special, of the late Prof. Graham. The truths he established respecting the hydration of compounds, the transpiration and the diffusion of liquids, the transpiration and the diffusion of gases, the dialysis of liquids and the dialysis of gases, and the occlusion of gases by metals, are all of them cardinal truths. And even of still greater value is his luminous generalization respecting the crystalloid colloid states of matter—a generalization which, besides throwing light on many other phenomena, has given us an insight into organic processes previously incomprehensible. These results, reached by his beautifully-coherent series of researches extending over forty years, constitute a new revelation of the properties of matter.

Neither is it true that in advancing the Concrete Sciences we have failed to do our share. Take the first in order—Astronomy. Though, for the long period during which our mathematicians were behind, Planetary Astronomy progressed but little in England, and the development of the Newtonian theory was left chiefly to other nations; yet of late there has been no want of activity. When I have named the inverse problem of perturbations and the discovery of Neptune, the honor of which we share with the French, I have called to mind an achievement sufficiently remarkable. To Sidereal Astronomy we have made great contributions. Though the conception of Wright, of Dur ham, respecting stellar distribution was here so little attended to that, when afterward enunciated by Kant (who knew Wright's views), and by Sir W. Herschel, it was credited to them; yet since Sir W. Herschel's time the researches in Sidereal Astronomy, by Sir John Herschel and others, have done much to further this division of the science. Quite recently the discoveries made by Mr. Huggins respecting the velocities with which certain stars and nebulæ are approaching us and others receding, have opened a new field of inquiry; and the inferences reached by Mr. Proctor respecting the "drifting" of star-groups, now found to harmonize with the results otherwise reached by Mr. Huggins, go far to help us in conceiving the constitution of our galaxy. Nor must we forget how much has been done toward elucidating the physical constitutions of the heavenly bodies as well as their motions: the natures of nebulæ, and the processes going on in sun and stars, have been greatly elucidated by Huggins, Lockyer, and others.

In Geology, the progress made here, and especially the progress in geological theory, is certainly not less—good judges say much greater —than has been made elsewhere. Just noting that English geology goes back to Ray, whose notions were far more philosophical than

those set forth long afterward by Werner, we come to Hutton, with whom in fact rational geology commences. For the untenable Neptunist hypothesis, asserting a once-universal aqueous action unlike the present, Hutton substituted an aqueous action, marine and fluviatile, continuously operating as we now see it, antagonized by a periodic igneous action: he recognized denudation as producing mountains and valleys; he denied so-called primitive rocks; he asserted metamorphism; he taught the meaning of unconformity. Since his day rapid advances in the same direction had been made. William Smith, by establishing the order of superposition of strata throughout England, prepared the way for positive generalizations; and, by showing that contained fossils are better tests of correspondence among strata than mineral characters, laid the basis for subsequent classifications. The better data thus obtained, theory quickly turned to account. In his "Principles of Geology," Lyell elaborately worked out the uniformitarian doctrine—the doctrine that the earth's crust has been brought to its present complex structure by the continuous operation of forces like those we see still at work. More recently, Prof. Ramsay's theory of lake-formation by glaciers has helped in the interpretation; and by him, as well as by Prof. Huxley, much has been done toward elucidating past distributions of continents and oceans. Nor must we forget Mallet's "Theory of Earthquakes"—the only scientific explanation of them yet given. And there must be added another fact of moment. Criticism has done far more here than abroad, toward overthrowing the crude hypothesis of universal "systems" of strata, which succeeded the still cruder hypothesis of universal strata, enunciated by Werner.

That our contributions to Biological Science have in these later times not been unimportant, may, I think, be also maintained. Just noting that the "natural system" of plant-classification, though French by development, is English by origin, since Ray made its first great division, and sketched out some of its subdivisions, we come, among English botanists, to Brown. He made a series of investigations in the morphology, classification, and distribution of plants, which in number and importance have never been equalled: the "Prodromus Floræ Novæ-Hollandia" is the greatest achievement in classification since Jussieu's "Natural Orders." Brown, too, it was who solved the mystery of plant-fertilization. Again, there is the conception that existing plant-distribution has been determined by past geological and physical changes—a conception we owe to Dr. Hooker, who has given us sundry wide interpretations in pursuance of it. In Animal-physiology there is Sir Charles Bell's discovery respecting the sensory and motor functions of the nerve-roots in the spinal cord; and this underlies multitudinous interpretations of organic phenomena. More recently we have had Mr. Darwin's great addition to biological science. Following in the steps of his grandfather, who had anti-

cipated Lamarck in enunciating the general conception of the genesis of organic forms by adaptive modifications, but had not worked out the conception as Lamarck did, Mr. Darwin, perceiving that both of them were mistaken in attributing the modifications to causes which, though some of them true, were inadequate to account for all the effects, succeeded, by recognizing the further cause he called Natural Selection, in raising the hypothesis from a form but partially tenable to a quite tenable form. This view of his, so admirably worked out, has been adopted by the great majority of naturalists; and, by making the process of organic evolution more comprehensible, it is revolutionizing biological conceptions throughout the world. In the words of Prof. Cohn, "no book of recent times has influenced the conceptions of modern science like the first edition of Charles Darwin's 'Origin of Species.'"[1] Nor should we overlook the various kindred minor discoveries, partly dependent, partly independent: Mr. Darwin's own respecting the dimorphism of flowers; Mr. Bates's beautiful interpretation of mimicry in insects, which led the way to many allied interpretations; Mr. Wallace's explanations of dimorphism and polymorphism in *Lepidoptera*. Finally, Prof. Huxley, besides dissipating some serious biological errors of Continental origin, has made important contributions to morphology and classification.

Nor does the balance turn against us on passing to the next highest concrete science. After those earlier inquiries by which Englishmen so largely advanced the Science of Mind, and set up much of the speculation subsequently active in France and Germany, there came a lull in English thinking; and during this arose the absurd notion that the English are not a philosophical people. But the lull, ending some forty years ago, gave place to an activity which has quickly made up for lost time. On this point I need not rest in assertion, but will quote foreign testimony. The first chapter of Prof. Ribot's work, "*La Psychologie Anglaise Contemporaine*," begins thus:

"'The sceptre of Psychology,' says Mr. Stuart Mill, 'has been decidedly restored to England.' It might be held that it had never passed out of her hand. Certainly, psychological studies are now pursued in that country by men of the first mark, who, by the solidity of their method, and, what is rarer still, by the precision of their results, have brought about a new era for science; but we might call this a reduplication rather than a renewal of former glory.'"

Similarly, on turning to Ethics considered under its psychological aspect, we find foreign testimony that English thinkers have done most toward the elaboration of a scientific system. In the preface to his late work, "*La Morale nella Filosofia Positiva*" (meaning, by "*Positiva*," simply scientific), Prof. Barzellotti, of Florence, states

[1] "*Die Entwicklung der Naturwissenschaft in den letzten fünfundzwanzig Jahren.*" By Prof. Dr. Ferdinand Cohn. Breslau, 1872.

that for this reason he limits himself to an account of English speculation in this department.[1]

And then, if, instead of Psychology and Ethics, Philosophy at large comes in question, there is independent testimony of kindred nature to be cited. Thus, in the first number of *La Critique Philosophique*, published under the direction of M. Rénouvier, the acting editor, M. Pillon writes:

"In England a great amount of work is done in the field of thought. . . . Not alone does England surpass France in ardor and in work (for that is not saying much), and in the interest attaching to the researches and discussions of her thinkers: she even surpasses Germany itself in this last point."

And still more recently M. Martis, in the leading French periodical, has been referring to—

"The new ideas which have sprung up in free England, and which are destined one day to metamorphose the natural sciences."[2]

So that, while Mr. Arnold is lamenting the want of ideas in England, it is discovered abroad that the genesis of ideas here is extremely active. While he thinks our ideas are commonplace, our neighbors find them new, to the extent of being revolutionary. Oddly enough, at the very time when he is reproaching his countrymen with lack of *geist*, Frenchmen are asserting that there is more *geist* here than elsewhere! Nor is there wanting other testimony of kindred nature. In the lecture above cited, Dr. Cohn, while claiming for Germany a superiority in the number of her earnest workers, says that "England especially has always been, and is particularly now, rich in men whose scientific works are remarkable for their astonishing laboriousness, clearness, profundity, and independence of thought"—a further recognition of the truth that the English, instead of drudging along the old ruts of thought, are distinguished by their ability in striking out new tracks of thought.

In his essay on the "Functions of Criticism at the Present Time," Mr. Arnold insists that the thing most needful for us now, in all branches of knowledge, is "to see the object as in itself it really is;" and in "Friendship's Garland," his *alter ego*, Arminius exhorts our Philistinism "to search and not rest till it sees things more as they really are." Above, I have done that which Mr. Arnold urges; not by picking up stray facts, but by a systematic examination. Feeling sure that Mr. Arnold has himself taken the course he advises, and is, therefore, familiar with all this evidence, as well as with the large quantity which might be added, I am somewhat puzzled on finding him draw from it a conclusion so different from that which presents itself to me. Were any one, proceeding on the foregoing data, to assert that, since the beginning of this century, more has been done in Eng-

[1] His reasons for this valuation are more fully given at p. 143.

[2] *Revue des Deux Mondes*, 1 Fevrier, 1873, p. 731.

land to advance scientific knowledge than has ever been done in a like interval, at any time, in any country, I should think his inference less wide of the truth than that which, strange to say, Mr. Arnold draws from the same data.

And now to consider that which more immediately concerns us—the effect produced by the bias of anti-patriotism on sociological speculation. Whether in Mr. Arnold, whom I have ventured to take as a type, the leaning toward national self-depreciation was primary and the overvaluing of foreign institutions secondary, or whether his admiration of foreign institutions was the cause and his tendency to depreciatory estimates of our social state the effect, is a question which may be left open. For present purposes it suffices to observe that the two go together. Mr. Arnold is impatient with the unregulated, and, as he thinks, anarchic state of our society; and everywhere displays a longing for more administrative and controlling agencies. "Force till right is ready," is one of the sayings he emphatically repeats; apparently in the belief that there can be a sudden transition from a coercive system to a non-coercive one—ignoring the truth that there has to be a continually-changing compromise between force and right, during which force decreases step by step, as right increases step by step, and during which every step brings some temporary evil along with its ultimate good. Thinking more force needful for us, and lauding institutions which exercise it, Mr. Arnold holds that even in our literature we should benefit by being under authoritative direction. Though he is not of opinion that an academy would succeed here, he casts longing glances at the French Academy, and wishes we could have had over us an influence like that to which he ascribes certain excellences in French literature.

The French Academy was established, as he points out, "to work, with all the care and all the diligence possible, at giving sure rules to our language, and rendering it pure, eloquent, and capable of treating the arts and sciences." Let us consider whether it has fulfilled this intention, by removing the most conspicuous defects of the language. Down to the present time, there is in daily use the expression *qu'est ce que c'est*, and even *qu'est ce que c'est que cela?* If in some remote corner of England is heard the analogous expression—"What is that there here?" it is held to imply entire absence of culture: the use of two superfluous words proves a want of that close adjustment of language to thought which even partially-educated persons among us have reached. How is it, then, that though in this French there are five superfluous words (or six, if we take *cela* as two), the purifying criticism of the French Academy has not removed it from French speech—not even from the speech of the educated? Or why, again, has the Academy not condemned, forbidden, and so expelled from the language, the double negative? If among ourselves any one lets drop the sen-

tence, "I didn't say nothing," the inevitable inference is that he has lived with the ill-taught; and further, that in his mind words and ideas answer to one another very loosely. How is it, then, that in French, notwithstanding Academic control, this use of superfluous symbols of thought, which, logically considered, actually inverts the intended meaning, has continued—has become a rule instead of a solecism? Once more, why has not the French Academy systematized the genders? No one who considers language as an instrument of thought, which is good in proportion as its special parts are definitely adjusted to special functions, can doubt that a meaningless use of genders is a defect. It is undeniable that to employ marks of gender in ways always suggesting attributes that are possessed, instead of usually suggesting attributes that are not possessed, is an improvement. Having an example of this improvement before them, why did not the Academy introduce it into French? And then — more significant question still — how, without the aid of any Academy, came the genders to be systematized in English? Mr. Arnold, and those who, in common with him, seem to believe only in agencies that have visible organizations, might, perhaps, in seeking the answer to this question, lose faith in artificial appliances and gain faith in natural processes. For, as, on asking the origin of language in general, we are reminded that its complex, marvellously-adjusted structure has been evolved without the aid or oversight of any embodied power, Academic or other, so, on asking the origin of this particular improvement in language, we find that it, too, arose naturally, not artificially. Nay, more, it resulted from one of those unregulated, anarchic states which Mr. Arnold so much dislikes. Out of the conflict of Old-English dialects, sufficiently allied to coöperate, but sufficiently different to have contradictory marks of gender, there came a disuse of meaningless genders and a survival of the genders having meaning—a change which an Academy, had one existed here in those days, would doubtless have done its best to prevent; seeing that during the transition there must have been a disregard of rules, and apparent corruption of speech, out of which no benefit could have been anticipated.

Another fact respecting the French Academy is by no means congruous with Mr. Arnold's conception of its value. The compiling of an authoritative dictionary was a fit undertaking for it. Just recalling the well-known contrast between its dilatory execution of this undertaking, and the active execution of a kindred one by Dr. Johnson, we have more especially to note the recent like contrast between the performances of the Academy and the performances of M. Littré. The Academy has long had in hand two dictionaries—the one a second edition of its original dictionary, the other an historical dictionary. The first is at letter D; and the initial number of the other, containing A—B, issued fifteen years ago, has not yet had a successor. Meanwhile, M. Littré, single-handed, has completed a dictionary which, besides doing all

that the two Academy dictionaries propose to do, does much more. With which marvellous contrast we have to join the startling fact, that M. Littré was refused admission to the Academy in 1863, and at length admitted in 1871 only after violent opposition.

Even if we pass over these duties which, in pursuance of its original purpose, the French Academy might have been expected to perform, and limit ourselves to the duty Mr. Arnold especially dwells upon—the duty of keeping "the fine quality of the French spirit unimpaired," and exercising "the authority of a recognized master in matters of tone and taste" (to quote his approving paraphrase of M. Rénan's definition)—it may still, I think, be doubted whether there have been achieved by it the benefits Mr. Arnold alleges, and whether there have not been caused great evils. That its selection of members has tended to encourage bad literature instead of good, seems not improbable when we are reminded of its past acts, as we are in the letter of Paul Louis Courier, in which there occurs this, among other passages similarly damaging:

"A duke and peer confers honor upon the French Academy which will have nothing to do with Boileau, rejects la Bruyère . . . . but readily admits Chapelain and Conrart. In like manner we see a viscount invited to the Acedémie grecque, but Corai repulsed, while Jornard comes in as though it were to work in a mill."

Nor have its verdicts upon great works been such as to encourage confidence: instance the fact that it condemned the "Cid" of Corneille, now one of the glories of French literature. Nor has its theory of art been beyond question. Upholding those canons of dramatic art which so long excluded the romantic drama, and maintained the feeling shown by calling Shakespeare an "inspired barbarian," may possibly have been more detrimental than beneficial. And when we look, not at such select samples of French literary taste as Mr. Arnold quotes, but at samples from the other extreme, we may question whether the total effect has been great. If, as Mr. Arnold thinks, France "is the country in Europe where the *people* is most alive," it clearly is not alive to the teachings of the Academy: witness the recent revival of the "Père Duchêne," the contents of which are no less remarkable for their astounding obscenity than for their utter stupidity. Nay, when we look only where we are told to look—only where the Academy exercises its critical function, we find reason for skepticism. Instance the late award of the Halpin Prize to the author of a series of poems called "L'Invasion," of which M. Patin, a most favorable critic, says:

"Their chief characteristic is a warmth of sentiment and a '*verve*,' which one would wish to see under more restraint, but against which one hesitates to set up, however just might be their application under other circumstances, the cold requirements of taste.'

Thus we have the Academy pandering to the popular feeling. The ebullitions of a patriotic sentiment which it is the misfortune of France to possess, in too great a degree, are not checked by the Academy, but encouraged by it, even at the expense of good taste.

And then, lastly, observe that some of the most cultivated Frenchmen, not so well satisfied with institutions of the Academy-type as Mr. Arnold seems to be, have recently established, on an English model, a French Association for the Advancement of the Sciences. Here are passages from their prospectus, published in *La Revue Scientifique*, 20 Janvier, 1872; commencing with an account of the founding of the Royal Institution:

"There were at this meeting fifty-eight members. Each one of these put down his name without more ado for fifty guineas, or nearly 1,300 francs of our money—equal to 2,000 francs at the present day. On the morrow the Royal Institution of London was established. We know what it came to be afterward.

"What Englishmen did, in 1799, some eminent *savants* of our own country would repeat to-day in France. Like Rumford, in the last century, they thought that the ancient supremacy of the French name in all branches of science was beginning to decay, and threatened one day to fall.

"God forbid that they should charge this decay upon the French Academy, of which they are themselves nearly all members! But the Academy, though it maintains the prestige of its name in Europe, is growing weak in the majesty of its greatness. It neither possesses sufficient means of action, nor is its energy sufficiently active to use those it has. The sinews of war—money—are lacking, but, what the Academy lacks still more, is bold and intelligent enterprise. It has fallen asleep upon the honors secured to it in the traditions of centuries."

Thus, curiously enough, we find another contrast parallel to that noted above. While Mr. Arnold is lauding French institutions, Frenchmen, recognizing their shortcomings, are adopting English institutions. From which we may fairly infer that, great as is Mr. Arnold's desire "to see the object as in itself it really is," he has not in this case succeeded; and that, endeavoring to escape the bias of patriotism, he has been carried too far the other way by the bias of anti-patriotism.

One more illustration of the effect of this bias on Mr. Arnold calls for brief comment. Along with his over-valuation of foreign regulative institutions, there goes an under-valuation of institutions at home which do not exhibit the kind of regulation he thinks desirable, and stand in the way of authoritative control. I refer to those numerous Dissenting organizations characterizing this "anarchy" of ours, which Mr. Arnold curiously makes the antithesis to "culture."

Mr. Arnold thinks that, as a nation, we show undue faith in machinery:

"Faith in machinery is, I said, our besetting danger. . . . What is freedom but machinery? what is population but machinery? what is coal but ma-

chinery? what are railroads but machinery? what is wealth but machinery? what are religious organizations but machinery?" [1]

And in pursuance of this conception he instances the desire to get Church-rates abolished and certain restrictions on marriage removed, as proving undue belief in machinery among Dissenters; while his own disbelief in machinery he considers proved by wishing for stronger governmental restraints,[2] by lauding the supervision of an Academy, and by upholding a Church Establishment. I must leave unconsidered the question whether an Academy, if we had one, would authorize this use of language, which makes it seem that voluntary religious agency is machinery and that compulsory religious agency is not machinery. I must pass over, too, Mr. Arnold's comparision of Ecclesiasticism and Nonconformity in respect of the men they have produced. Nor have I space to examine what he says about the mental attitudes of the two. It must suffice to say that, were the occasion fit, it might be shown that his endeavor "to see the object as in itself it really is" has not succeeded much better in this case than in the cases above dealt with. Here I must limit myself to a single criticism.

The trait which in Mr. Arnold's view of Nonconformity seems to me most remarkable is, that in breadth it so little transcends the view of the Nonconformists themselves. The two views greatly differ in one respect—antipathy replaces sympathy; but the two views are not widely unlike in extension. Avoiding that provincialism of thought which he says characterizes Dissenters, I should have expected Mr. Arnold to estimate Dissent, not under its local and temporary aspect, but under its general aspect as a factor in all societies at all times. Though the Nonconformists themselves think of Nonconformity as a phase of Protestantism in England, Mr. Arnold's studies of other nations, other times, and other creeds, would, I should have thought, have led him to regard Nonconformity as a universal power in societies, which has in our time and country its particular embodiment, but which is to be understood only when contemplated in all its other embodiments. The thing is one in spirit and tendency, whether shown among the Jews, or the Greeks—whether in Catholic Europe, or in Protestant England. Wherever there is disagreement with a current belief, no matter what its nature, there is Nonconformity. The open expression of difference, and avowed opposition to that which is authoritatively established, constitutes Dissent, whether the religion be Pagan or Christian, Monotheistic or Polytheistic. The relative attitudes of the dissenter and of those in power are essentially the same in all cases; and in all cases lead to persecution and vituperation. The Greeks who poisoned Socrates were moved by just the same sentiment as the Catholics who burnt Cranmer, and the Protestant Churchmen who imprisoned Bunyan and pelted Wesley. And, while the manifestations of feeling are essentially the same, while the accom-

[1] "Culture and Anarchy," p. 16. [2] Ibid., pp. 130–140.

panying evils are essentially the same, the resulting benefits are essentially the same. Is it not a truism that without divergence from that which exists, whether it be in politics, religion, manners, or any thing else, there can be no progress? And is it not an obvious corollary that the temporary evils accompanying the divergence, are outbalanced by the eventual good? It is certain, as Mr. Arnold holds, that subordination is essential; but it is also certain that insubordination is essential—essential, if there is to be any improvement. There are two extremes in the state of a social aggregate, as of every other aggregate, which are fatal to evolution—rigidity and incoherence. A medium plasticity is the healthful condition. On the one hand, a force of established structures and habits and beliefs, such as offers considerable resistance to change; on the other hand, an originality, an independence, and an opposition to authority, energetic enough to overcome the resistance little by little. And, while the political nonconformity we call Radicalism has the function of thus gradually modifying one set of institutions, the religious nonconformity we call Dissent has the function of thus gradually modifying another set.

That Mr. Arnold does not take this entirely-unprovincial view, which would lead him to look on Dissenters with less aversion, may in part, I think, be ascribed to that over-valuation of foreign restraints and under-valuation of home freedom, which his bias of anti-patriotism fosters; and serves further to illustrate the disturbing effects of this bias on sociological speculation.

And now to sum up this somewhat too elaborate argument. The general truth that, by incorporation in his society, the citizen is in a measure incapacitated for estimating rightly its characters and actions in relation to those of other societies, has been made abundantly manifest. And it has been made manifest also that when he strives to emancipate himself from these influences of race, and country, and locality, which warp his judgment, he is apt to have his judgment warped in the opposite way. From the perihelion of patriotism he is carried to the aphelion of anti-patriotism; and is almost certain to form views that are more or less eccentric, instead of circular, all-sided, balanced views.

Partial escape from this difficulty is promised by basing our sociological conclusions chiefly on comparisons made among other societies —excluding our own. But even then these perverting sentiments are sure to intrude more or less; for we cannot contemplate the institutions of other nations without our sympathies or antipathies being in some degree aroused by consciousness of likeness or unlikeness to our own institutions. Discounting our conclusions as well as we may, to allow for the errors we are thus led into, we must leave the entire elimination of such errors to a future in which the decreasing antagonisms of societies will go along with decreasing intensities of these sentiments.

ENGLISH AND AMERICAN SCIENCE.[1]

By JOHN W. DRAPER, LL. D.

MR. PRESIDENT: When I was in London a year or two ago, I passed some pleasant hours with my friend Prof. Tyndall. Among these, I think that, perhaps, the most pleasant were those of one afternoon that we spent together in the laboratory of the Royal Institution, where Davy discovered potassium and sodium, and decomposed the earths; where Young first announced the grand and fertile principle of interference, and placed on firm foundations the wave-theory of light; where Faraday made his great discoveries in electricity and magnetism. On that occasion Dr. Tyndall was showing me some of his own splendid discoveries—the action of ether-waves of short period upon gaseous matter, clouds formed by actinic decomposition. I saw the superb sky-blue light, and verified its polarized condition. It was like the light of heaven.

Well, as I laid down the Nicol prism we had been using, I could not help thinking that there was an unseen "presence" in the place—a *genius loci*—that inspired men to make such discoveries. Who was it that brought that genius there?

At the time of the American Revolution, there resided in the town of Rumford, N. H., one Benjamin Thompson, who occupied himself in teaching a school. He embraced, as we Americans would say, the wrong side of the question on that occasion—he sided with the king's government. He went to England, became a man of mark, and was knighted. Then he went on the Continent, again distinguished himself by his scientific attainments, again was titled, and this time, in memory of his American home, was called Count Rumford.

On his return to London, Count Rumford founded the Royal Institution, and thus to a native American the world owes that establishment which has been glorified by Davy, and Young, and Faraday, and the lustre of which is now so conspicuously maintained by Tyndall. Had it not been for Rumford, Davy might have spent his life in filling gas-bags for Dr. Beddoes's patients; Faraday might have been a book-binder, and certainly Tyndall would not have been honoring us with his presence here to-night.

But if Benjamin Thompson, an American, founded the Royal Institution, James Smithson, an Englishman, shortly afterward founded that noble institution in Washington which bears his name, and which, under the enlightened care of Prof. Henry, has so greatly ministered to the advancement and diffusion of science. You, sir, have called on me to respond to your toast, "English and American Science," and I think these facts show you how closely they have been associated.

[1] Address at the Tyndall Banquet.

Now, Prof. Tyndall is on the point of leaving us. When he gets back to Albemarle Street, he will remember Broadway. I am sure that you will all join me in wishing him a pleasant voyage over the Atlantic. But I wish him something better than that, I will add—a safe return to America. There is a great deal for him to do here yet. He may tell his friends that he has been to America, but he must not tell them that he has seen the Americans. We who are living on the Atlantic verge of the continent are only modified Europeans—very slightly modified, indeed. One must go beyond the Alleghanies—yes, and over to the Pacific coast, before he can say he has seen what the American really is. I suppose that Dr. Tyndall has finished his glacier expeditions to Switzerland. Is there nothing here that can tempt him? He and other members of the Alpine Club need not go about the streets of London weeping, like so many broken-hearted Alexanders, that there are no more worlds to conquer. Let them take a look at the Rocky Mountains, and tell us what they think of them. Dr. Tyndall is a lover of Nature. Well! we can show him all kinds of scenery, from where the half-frozen Mackenzie is lazily flowing through a waste of snows on its way toward the Arctic Ocean, to where oranges are growing on the Gulf. Or, if he is tired of inanimate Nature, and is in the mood of Dr. Johnson—you know the story. Boswell said to Johnson one day: "See! What a beautiful afternoon; let us take a walk in the green fields." "No, I won't," replied the grim and gruff lexicographer. "I've seen green fields; one green field is like another green field. They are all alike. No, sir! I'll walk down Cheapside. I like to look at men"—if Dr. Tyndall is in that mood, can we not satisfy his curiosity? Another friend of mine, Mr. Froude, has set us all talking about Ireland. We can show Dr. Tyndall how we take the Irish immigrant, in his corduroy knee-breeches, his smashed-down hat, and his shillalah in his fist, and, in a generation or so, turn him into an ornament of professional life, make him a successful merchant, or familiarize him with all the amenities of elegant society. If that's not enough, we will show him how we take the German, and, wonderful to be said, make him half forget his fatherland and half his mother-tongue, and become an English-speaking American citizen. If that's not enough, we will show him how we have purged the African, the woolly-headed black man, of the paganism of his forefathers, and are now trying our hand at Darwinizing him into a respectable voter. If that's not enough, we will show him how, in the trans-Mississippi plains, we are improving the red Indian—alas! I fear my friend will say, improving him off the face of the earth! If that's not enough, we will show him where we have got tens of thousands of Chinese, with picks and shovels, digging Pacific railways. We are mixing European and Asiatic, red Indians and black Africans, together, and I suppose certain English naturalists will tell us that the upshot of the thing will be a survival of the fittest. In San Francisco,

we can show Dr. Tyndall the church, the chapel, the joss-house, all in a row, and, perhaps, considering his forlorn, celibate condition, he may be conscience-stricken when we display before his astonished eyes the much-married men of Mormondom.

Nowhere in the world are to be found more imposing political problems than those to be settled here; nowhere a greater need of scientific knowledge. I am not speaking of ourselves alone, but also of our Canadian friends, on the other side of the St. Lawrence. We must join together in generous emulation of the best that is done in Europe. In her Majesty's representative, Lord Dufferin, they will find an eager appreciation of all that they may do. Together we must try to refute what De Tocqueville has said about us: that communities such as ours can never have a love of pure science. But, whatever may be the glory of our future intellectual life, let us both never forget what we owe to England. Hers is the language that we speak; hers are all our ideas of liberty and law. To her literature, as to a fountain of light, we repair. The torch of science that is shining here was kindled at her midnight lamp.

SCIENCE AND PUBLIC AFFAIRS.[1]

By President ANDREW D. WHITE,
of Cornell University.

MR. CHAIRMAN: There is a legend well known to most of us—and which has an advantage over most legends in that it is substantially true—that a very distinguished man of science in this country was once approached by an eminent practical man, and urged to turn his great powers in scientific investigation and exposition to effect in making a fortune.

And, to the great surprise of that man of business, the man of science responded, "But, my dear sir, *I have no time to waste in making money.*"

Of all the recent great results of science, I think, sir, that those words have struck deepest and sped farthest in the average carnal mind on our side the Atlantic.

"No time to waste in making money!" I have stood sir, in the presence of a very eminent man of affairs—one whose word is a power in the great marts of the world, and watched him as he heard for the first time this astonishing *dictum*. He stood silent—apparently in awe. The words seemed to reverberate among the convolutions of his brain, and to be reëchoed far away, back, from depth to depth, among the deepest recesses of his consciousness—"No time to waste in making money!"

[1] Address at the Farewell Banquet to Professor Tyndall.

The honored guest of this evening comes among us as another of those men who, in following a very high vocation, have given no thought to money-getting.

Of course, indirectly, his brilliant discoveries have, in many cases, aided to heap up gold in the world's coffers, but that has not been the direct object of his life-work. As to the money value of most of his discoveries, you might as well try to fix the worth of a fixed star, or a baby. His career has been that of a seeker for new truth—and an eloquent proclaimer of it; and it is in this apostolate that he has been so warmly welcomed in this great metropolis of money-making.

The toast, sir, to which you ask me to speak is, "The Relation of Science to Political Progress."

Now, sir, I maintain that the true spirit of scientific research—incarnate before us in our honored guest—embracing as it does zeal in search for truth, devotion to duty which such a search imposes, faith in good as the normal and necessary result of such a search—that such a spirit is, at this moment, one of the most needed elements in the political progress of our country.

I might go on to show how usefully certain scientific methods might be brought to bear on the formation of political judgments, and in determining courses of political action. I might show how even a very moderate application of scientific principles would save us from what is constantly going on in municipal, State, or national legislation —the basing of important statutes to-day, on the supposition that two and two make four, and to-morrow on the theory that two and two make forty; but the hour is late, and I spare you; I will confine myself simply to the value, in our political progress, of the spirit and example of our honored friend, and of those like him.

What is the example which reveals that spirit? It is an example of *zeal*—zeal in search for the truth, *sought for truth's sake*—and not for the sake of material advantage; it is an example of *thoroughness* —of the truth sought in its wholeness, not in dilutions or adaptations, or suppressions, supposed to be healthy for this man's mind, or that man's soul; it is an example of *bravery*—the fearlessness that leads a truth-seeker to brave all outcry and menace; it is an example of *devotion to duty;* without which, for a steady force, as Prof. Tyndall just now observed, no worthy scientific work can be accomplished; and, finally, an example of *faith*—of a high and holy faith that the results of earnest truth-seeking cannot be other than good—faith that truth and goodness are inseparable—faith that there is a Power in the universe which forbids any honest truth-seeking to lead to lasting evil. A faith, this is, which has had its "noble army of martyrs" from long before Roger Bacon down to this present—martyrs not less real than that devoted saint, from whom, as I understand, our guest takes his name, who perished in the flames as a martyr to religious duty.

What I maintain then, is, that this zeal for truth as truth, this faith

in the good as forever allied to the true, this devotion to duty as the result of such faith and zeal, constitute probably the most needed element at this moment in the political regeneration of this country, and that, therefore, the example of our little army of true devotees of science has an exceeding preciousness.

Said a justly-distinguished senator to me yesterday, in Washington: "The true American idea of education is to give all children a good and even start; then to hold up the prizes of life before them; then to say to them: 'Go in and win; let the smartest have the prizes.'"

Who of the common herd shall dispute the conclusions of a senator beneath the great cast-iron dome at Washington?—But here, in this presence, I may venture to say that such a theory of education is one of the main causes of our greatest national danger and disgrace. No theory can be more false, or, in the long-run, more fatal. Look at it for a moment:

We are greatly stirred, at times, as this fraud or that scoundrel is dragged to light, and there rise cries and moans over the corruption of the times; but, my friends, these frauds and these scoundrels are not the "corruption of the times." They are the mere pustules which the body politic throws to the service. Thank God, that there is vitality enough left to throw them to the surface! The disease is below all this; infinitely more wide-spread.

What is that disease? I believe that it is, first of all, *indifference*—indifference to truth as truth; next, *skepticism*, by which I do not mean inability to believe this or that dogma, but the skepticism which refuses to believe that there is any power in the universe strong enough, large enough, good enough, to make the thorough search for truth safe in every line of investigation; next, *infidelity*, by which I do not mean want of fidelity to this or that dominant creed, but want of fidelity to that which underlies all creeds, the idea that the true and the good are one; and, finally, *materialism*, by which I do not mean this or that scientific theory of the universe, but that devotion to the mere husks and rinds of good, that struggle for place and pelf, that faith in mere material comfort and wealth, which eats out of human hearts all patriotism, and which is the very opposite of the spirit that gives energy to scientific achievement.

The education which our senatorial friend approved leads naturally to just this array of curses.

On the other hand, I believe that the little army of scientific men furnish a very precious germ from which better ideas may spring.

And we should strengthen them. We have already multitudes of foundations and appliances for the dilution of truth—for the stunting of truth—for the promotion of half-truths—for the development of this or that side of truth.

We have no end of intellectual hot-house arrangements for the cultivation of the plausible rather than the true; and therefore it is that

we ought to attach vast value to the men who with calmness and determination seek THE TRUTH, in its wholeness, on whatever line of investigation, not diluting it or masking it.

Their zeal, their devotion, their faith, furnish one of those very protests which are most needed against that low tone of political ideas which in its lower strata is political corruption. Their life gives that very example of a high spirit, aim, and work, which the time so greatly needs.

In this view, then, sir, do I most heartily welcome our friend as a strong leader—not only in scientific, but in political and general progress. His influence has spread far beyond his lecture-room; nay, it shall spread far beyond those who have read or shall read his lectures.

I might speak of his quickening influence on one body of men—five hundred strong—assembled in one of our newer institutions of learning. But that influence extends far beyond those who stand in institutions of learning. The reverence for scientific achievement, the revelation of the high honors which are in store for those who seek for truth in science—the inevitable comparison between a life devoted to that great pure search, on one hand, and a life devoted to place-hunting or pelf-grasping on the other—all these shall come to the minds of thoughtful men in lonely garrets of our cities, in remote cabins on our prairies, and thereby shall come strength and hope for higher endeavor.

And, Mr. Chairman, as this influence for good spreads and strengthens, I have faith that gratitude will bring in results for political good of yet another kind.

Many predecessors of our friend have, as literary men, strengthened the ties that bind together the old land and the new; and I trust that love, admiration, and gratitude, between men of science on both sides the Atlantic, which our guest has done so much to arouse, may add new cords and give strength to old cords which unite the hearts of the two great English-speaking nations.

DISCOVERY OF MOUNT TYNDALL.[1]

BY PROF. WILLIAM H. BREWER,
OF THE YALE SCIENTIFIC SCHOOL.

MY DEAR SIR: In answer to yours of the 6th, I may say that, being familiar with all the circumstances relating to the discovery and naming of *Mount Tyndall*, I was asked to respond to a toast alluding to this, at the dinner given in honor of Prof. Tyndall on the 4th, but which want of time prevented being called for. You now ask me for an abstract of what I intended to say. I will give it (as nearly as I can), and this the more willingly, as his success, as a

[1] Letter to Prof. Mayer, Secretary to Committee of the Tyndall Banquet.

mountaineer was not even alluded to by any of the speakers, nor was the fact that, in recognition of his discoveries in the Alps, one of the highest peaks in our country has been named for him.

In 1864 I had charge of a party exploring the group of highest peaks of the Sierra Nevada, in California—the highest, in fact, in the United States. For several years I had been familiar with its distant aspects, as seen from nearly every side. The group was entirely unknown, however, so far as any accurate knowledge of its height, topography, or interior scenery, was concerned. Previous attempts to reach it had failed. Once we had been prevented by floods, and once turned from its flanks by hostile Indians. But this time we were more successful. Our camp was at 10,000 feet elevation, the deep, blue-black canopy of sky our only shelter. From this point our first attempt failed. Two of us reached an altitude of nearly 14,000 feet, only to find the crest nearly five miles beyond, and separated from us by a cañon 3,000 or more feet deep, with vertical precipices of perhaps 1,000 feet below us, and, still farther below, frozen lakes of vivid blue. We turned back, weary and dispirited.

That night, the intrepid Clarence King earnestly begged that he be permitted to try, with Cotter, to reach the summit. I hesitated. We were short of provisions, and far from supplies. Moreover, I had seen the difficulties, and he had not, but he had read Tyndall's "Glaciers of the Alps," and thought no place inaccessible. Permission was at length given, but this meant partial starvation to those of us remaining, that they might have the necessary food, and to those who went it meant fatigue, sleeping among the rocks at 11,000 or 12,000 feet, hard climbing, and doubtful success.

Early dawn of July 4th found us on the way, with instruments and six days' provisions. We carried their packs up to 13,000 feet, to lighten their labors, then pointed out the way they must take, and, after a hearty shake of the hand, saw them descend into the cañon and disappear. The evening of the fifth day saw their return; they had reached the summit, and were back in safety. By the light of the camp-fire that night I calculated the height as well as I could from their observations. It was the highest unnamed peak that had yet been measured in the country, so we called it Mount Tyndall.

This peak now finds a place on our maps. Its position is about latitude 36° 39′ north, longitude 118° 19′ west, and its height 14,386 feet. It is one of a group of peaks, several of which are above 14,000 feet, amid the most sublime surroundings. The peaks are buttressed with ridges of granite, streaked with the snows of ages, and furrowed with cañons, the desolation of the scene increased rather than relieved by the many little blue lakes that repose in the ancient glacier-beds. This group is a part of that chain which stretches from Cape Horn to Behring's Straits, the grandest mountain-system on our planet. Here is the monument bearing the name of our honored guest.

Prof. Tyndall's books are now so widely read that the name is almost a household word where our common language is spoken. We cannot hope that it will be so a hundred years hence; with the advance of scientific knowledge, the new generations will read new books, and ours be buried or partially hidden in the great ocean of scientific literature. But I look forward in imagination, and see that the man will not be forgotten; he will be remembered as one who loved and advanced science. This peak will perhaps still more keep his memory green, and the coming generations of school-children conning their lessons in geography, and philosophers studying the grander features of our globe, will learn to pronounce the name of one who loved mountains even as he loved science.

SKETCH OF PROFESSOR HENRY.

PROF. JOSEPH HENRY, who is widely known throughout the scientific world for his various original investigations, and as the organizer and Permanent Secretary of the Smithsonian Institution, is of Scotch descent, and was born in Albany, in the State of New York. Having lost his father in early childhood, he was sent at the age of seven years to live with his grandmother, and to attend school at Galway, in Saratoga County, where he remained until he was fourteen. Having accidentally and secretly obtained access to the village library, he became fascinated with books of fiction, and devoted much of his time to reading. Returning to Albany, he was apprenticed to the trade of a jeweller, with which he was occupied two years. He afterward developed a passion for serious study, and became teacher of a country district school. He studied for a time in the Albany Academy, and, through the recommendation of its principal, Dr. T. Romeyn Beck, was appointed private tutor in the family of General Stephen Van Rensselaer, the patroon of Rensselaerwyck. There his duties occupied him three hours a day, and the rest of his time was spent as an assistant to Dr. Beck, in his chemical investigations; but he also studied anatomy and physiology, with a view to graduating in medicine. He, however, obtained a position as an engineer to survey a route for a State road from the Hudson River to Lake Erie, through the southern tier of counties. Having finished this arduous and responsible labor, he was elected to fill the vacant chair of Mathematics in the Albany Academy. As the duties did not begin immediately, he spent several months exploring the geology of New York State with Prof. Eaton, of the Rensselaer Institute of Troy. He entered upon his work at the academy in 1826, and then commenced a course of

original investigations on electricity and magnetism, the first regular series on Natural Philosophy which had been prosecuted in this country since the days of Franklin. These researches made him favorably known not only in this country, but in Europe, and led to his call in 1832 to the chair of Natural Philosophy in the College of New Jersey, at Princeton.

In the first year of his course in this institution, during the absence of the Professor of Chemistry, Dr. Torrey, in Europe, he gave lectures in Natural Philosophy, Chemistry, Mineralogy, Geology, Astronomy, and Architecture. This work interrupted his original investigations, but he soon commenced anew where he had left off at Albany, and devoted himself to a work of research, until he was called to his present position in Washington. In 1835 he was granted by the trustees of the college a year's absence in Europe, nine months of which he spent principally in Paris, London, and Edinburgh, in intercourse with the *savants* of these cities, and procuring more efficient apparatus to prosecute his investigations.

Meantime Mr. John Smithson, of England had left a large sum of money to the Government of the United States, to be devoted "to the increase and diffusion of knowledge among men." An institution was projected to carry out this purpose, and in 1846 Prof. Henry was requested by some of the members of the Board of Regents to give his views as to the best methods of realizing the intentions of its founder. In compliance with this request he gave an exposition of the will, and of the method by which it might most efficiently be realized. On account of this exposition and his scientific reputation, he was called to the office of Secretary or Director of the establishment. Unfortunately, Congress had attempted to organize the institution without a due appreciation of the terms of the will. This gave rise to difficulties and expenditures on local objects, particularly to the commencement of a very expensive building, which have much retarded the full realization of what might have been produced by the plan originally proposed by Prof. Henry.

At the time of the organization of the Light-House Board of the United States, Prof. Henry was appointed by President Fillmore one of its members, and he still continues in the position. During the war he was appointed one of a commission, together with Prof. Bache and Admiral Davis, to examine and report upon various inventions, intended to facilitate the operations against the enemy, and to improve the art of navigation. On the death of Prof. Bache, he was elected President of the National Academy of Sciences, established by an act of Congress in 1863, to advance science, and to report upon such questions of a scientific character as might be connected with the operations of the Government. He is a member of various societies in this country and abroad, and has several times received the degree of LL. D., the last time from Cambridge, Massachusetts.

Prof. Henry was married in May, 1830, to Miss Alexander, of Schenectady, the sister of Prof. Alexander, of Princeton, and from the ardent devotion of his wife, and the fraternal sympathy of her brother in his pursuits, he has received assistance and support beyond that which usually fall to the lot of men. The most peaceful, and to himself the most profitable, part of his life was that spent in Princeton, for which place, and the college connected with it, he retains the warmest attachment.

The following is a brief enumeration of his scientific investigations and discoveries:

1. A sketch of the topography of the State of New York, embodying the results of the survey before mentioned.

2. In connection with Dr. Beck and the Hon. Simeon De Witt, the organization of the meteorological system of the State of New York.

3. The development, for the first time, of magnetic power, sufficient to sustain tons in weight, in soft iron, by a comparatively feeble galvanic current.

4. The first application of electro-magnetism as a power, to produce continued motion in a machine.

5. An exposition of the method by which electro-magnetism might be employed in transmitting power to a distance, and the demonstration of the practicability of an electro-magnetic telegraph, which, without these discoveries, was impossible.

6. The discovery of the induction of an electrical current in a long wire upon itself, or the means of increasing the intensity of a current by the use of a spiral conductor.

7. The method of inducing a current of quantity from one of intensity, and *vice versa*.

8. The discovery of currents of induction of different orders, and of the neutralization of the induction by the interposition of plates of metal.

The discovery that the discharge of a Leyden jar consists of a series of oscillations backward and forward until equilibrium is restored.

10. The induction of a current of electricity from lightning at a great distance, and proof that the discharge from a thunder-cloud also consists of a series of oscillations.

11. The oscillating condition of a lightning-rod while transmitting a discharge of electricity from the clouds causing it, though in perfect connection with the earth, to emit sparks of sufficient intensity to ignite combustible substances.

12. Investigations on molecular attraction, as exhibited in liquids, and in yielding and rigid solids, and an exposition of the theory of soap-bubbles. (These originated from his being called upon to investigate the causes of the bursting of the great gun on the United States steamer Princeton.)

13. Original experiments on, and exposition of, the principles of acoustics, as applied to churches and other public buildings.

14. Experiments on various instruments to be used as fog-signals.

15. A series of experiments on various illuminating materials for light-house use, and the introduction of lard-oil for lighting the coasts of the United States. This and the preceding in his office of chairman of the Committee on Experiments of the Light-House Board.

16. Experiments on heat, in which the radiation from clouds and animals in distant fields was indicated by the thermo-electrical apparatus applied to a reflecting telescope.

17. Observations on the comparative temperature of the sun-spots, and also of different portions of the sun's disk. In these experiments he was assisted by Prof. Alexander.

18. Proof that the radiant heat from a feebly luminous flame is also feeble, and that the increase of radiant light, by the introduction of a solid substance into the flame of the compound blow-pipe, is accompanied with an equivalent radiation of heat, and also that the increase of light, and radiant heat in a flame of hydrogen, by the introduction of a solid substance, is attended with a diminution in the heating power of the flame itself.

19. The reflection of heat from concave mirrors of ice, and its application to the source of the heat derived from the moon.

20. Observations, in connection with Prof. Alexander, on the red flames on the border of the sun, as observed in the annular eclipse of 1838.

21. Experiments on the phosphorogenic ray of the sun, from which it is shown that this emanation is polarizable and refrangible, according to the same laws which govern light.

22. On the penetration of the more fusible metals into those less readily melted, while in a solid state.

Besides these experimental additions to physical science, Prof. Henry is the author of twenty-five (1846–'71) reports, giving an exposition of the annual operations of the Smithsonian Institution. He has also published a series of essays on meteorology in the Patent-Office Reports, which, besides an exposition of established principles, contain many new suggestions; and, among others, the origin of the development of electricity, as exhibited in the thunder-storm; and an essay on the principal source of the power which does the work of developing the plant in the bud, and the animal in the egg.

He has also published a theory of elementary education, in his address as President of the American Association for the Advancement of Education, the principle of which is, that in instruction the order of Nature should be followed; that we should begin with the concrete and end with the abstract, the one gradually shading into the other; also the importance of early impressions, and the tendency in old age to relapse into the vices of early youth.

EDITOR'S TABLE.

OUR FIRST YEAR'S WORK.

WHEN THE POPULAR SCIENCE MONTHLY started, the public were informed that it would be published a year at any rate, and go on if fairly sustained; our second volume is now completed, and we are happy to announce that the enterprise will be continued, and gives promise of permanence. It was entered upon as an experiment, and generally thought to be a hopeless one. The quality of those periodicals which reach great circulation was pointed out as evidence of what the people demand, and we had the most discouraging assurances that they will not sustain a solid and really instructive magazine, which requires them to think. Believing, however, that there are large numbers who would gladly support such a monthly if they could get it, we determined to give them the chance, and have been justified in the result. Our MONTHLY is not only a success, but it has succeeded on its own merits alone. All the clap-trap artifices for rushing into a big circulation have been avoided: the public have neither been bribed by premiums, nor tempted by cheapness, nor lured by large promises, nor stunned by pictorial display, nor deafened by the trumpetings of self-praise, such as usually accompany the advent of new periodicals. We entered quietly upon the undertaking, and with its announcement the first number was ready, so that people might judge of it themselves. In our prospectus we said: "THE POPULAR SCIENCE MONTHLY will contain instructive and attractive articles and abstracts of articles, original, selected, and illustrated, from the leading scientific men of different countries, giving the latest interpretations of natural phenomena, explaining the applications of science to the practical arts, and to the operations of domestic life.

"It is designed to give especial prominence to those branches of science which help to a better understanding of the nature of man; to present the claims of scientific education, and the bearings of science upon questions of society and government; how the various subjects of current opinion are affected by the advance of scientific inquiry will also be considered." We appeal to the two volumes of the MONTHLY now completed in proof that these pledges have been fairly redeemed.

In stating that our enterprise is an undoubted success, it will, of course, not be understood that we have a circulation at all comparable with that of the leading periodicals devoted to light literature, but it is greater than was anticipated, and is steadily increasing. The undertaking has, moreover, met with wide sympathy and warm encouragement from the most intelligent class of readers throughout the country. There has been an almost unanimous expression of opinion on the part of individuals and the press that THE POPULAR SCIENCE MONTHLY has met an urgent public need, that it is the most valuable magazine now before the American public, and deserves an extensive patronage. For all these kind expressions, and for the substantial support which has accompanied them, we return to our friends the most cordial thanks.

But, while our work has been thus far approved, we are far from claiming that it has been perfect. It has the imperfections which are incident to a new project in a new field, and which it will require time and experience to remove. We intend to improve it in several important features. While pursu-

ing the general plan now entered upon, we expect to enlarge its resources, to make more prominent the applications of science to common life, to give a more popular form to its discussions, and, in short, to make it a magazine that no family with brains in it can afford to do without.

Our object will continue to be to furnish a higher grade of reading for purposes of public instruction. In this matter the press of the country has been false to its trust. We have an educational system that brings the whole mass of the people up to the reading-point, and hardly carries them beyond it. The school-master, when he has done with them, hands his pupils over to the editors, and the Dailies, Weeklies, and Monthlies, go on with the work of education. In the school they are taught to worship books, and to consider print and wisdom as synonymous, so that there arises a superstition that mere reading is an intellectual virtue. Were the supreme object of education to make customers for newspapers, our system could hardly be improved. But how does the press meet its responsibilities and use its power? With rare exceptions, it must be said, by ministering to popular weaknesses. Editors fill their pages with worthless gossip, with interminable comment on passing frivolities, with trashy and demoralizing fictions, with the lies, libels, and multitudinous inanities of politics, and with endless, ambitious writing on every empty topic that will serve to make a sensation and beguile the reader without the exertion of thought. It is not in this way that the serious work of public education is to be carried forward. Excess of reading without regard to its quality is a pernicious dissipation, and, besides wasting precious time, it disqualifies those who indulge in it from that serious effort of thought which is the first condition of mental improvement. The main purpose in starting our magazine was to do something to counteract this baneful influence, to contribute something toward elevating the standard of popular reading, and to promote the higher ends of education by diffusing valuable knowledge, and making accessible the productions of the world's ablest thinkers.

A few have criticised the MONTHLY as containing too much foreign matter; but our aim is to get the best, be it foreign or domestic. In the interests of truth we have to guard against the "bias of patriotism," and all who do this will recognize that the leading intellectual work of the world is now done in Europe. A spurious patriotism fosters national jealousies and teaches us that foreigners are our enemies; but, in the sphere of science, the selfish and paltry antagonisms of men can be forgotten, and to talk about "foreigners" is impertinent. Our allegiance is to the age and to the growing spirit of liberality, which is its greatest honor. But we shall guard against undervaluing American scientific thought, and would refer to the present contents of the MONTHLY in attestation of this purpose.

Again thanking our friends for their generous encouragement, we ask for its continuance, and an increase of their efforts to promote the diffusion of our magazine. As it was for the people to decide whether it should be sustained, so it will be for them to enlarge the sphere of its usefulness by extending its circulation, and thus enabling us to carry out our plans for its improvement.

MR. GODWIN ON THE LIMITS OF SCIENCE.

MR. PARKE GODWIN, of the *Evening Post*, was chosen to speak for the press at the Tyndall banquet; but he saw fit to throw his toast behind him, and take up a more ambitious *rôle*. He used the occasion to give a lesson to the scientific gentlemen present as to the proper

limit of their inquiries. He staked out the ground within which all is legitimate, and beyond which all is mere fantastic pseudo-science and subversive of religious faith. It has ever been a favorite occupation with outsiders to instruct the investigators of Nature where they must stop, so that scientific progress has largely consisted in levelling barriers and establishing the rights of inquiry in forbidden places. Moreover, at each step of advance the pioneers of research have been bidden to stand, in the name of religion; so that in breaking down these restrictions advancing science has been simply widening the scope and liberty of religion itself.

Mr. Godwin may now speak with safety of the "roaring furnaces of the sun," but, for suggesting that the sun is a mass of incandescent matter Anaxagoras was accused of impiety and banished. Hipparchus, for making a catalogue of the stars, was denounced as impious. Galileo, for inquiring into the celestial motions, was anathematized as a heretic. Newton's theory of gravitation was branded as an atheistic attempt to explain the universe without the intervention of God. The early anatomists were charged with impiety for dissecting the human body. The first geologists incurred theological denunciation, and the abhorrence of the pious, as seeking to undermine the Bible and overthrow Christianity. But in each of these cases it turned out that the alarm of the religious was groundless, and every one of the departments of knowledge that science has created, the theologians, as soon as they got through denouncing it, have turned to account for their own purposes. But it seems that there is a class that cannot even learn in the school of experience. The next great step of progressive thought, the synthesis of the sciences, the unification of their facts and principles by the most comprehensive laws, so as to arrive at the philosophy of Nature on the basis of actual knowledge, is sternly contested, and we are to have the fight over again with the descendants of the old enemies of investigation, and on exactly the same grounds. Again, men of science are bidden to stand lest God be driven from the universe. Mr. Godwin appears as the champion of imperilled faith, and his speech is reëchoed and applauded by the press as a well-timed defence of religion against the inroads of "irreligious science." Let us briefly examine his argument.

After mentioning some examples of spurious science, Mr. Godwin says: "These are conjectures that impose upon us their own fantastic offspring for the legitimate heirs of science. Science is exact and certain and authoritative, because dealing with fact and the systematic coördination of facts only. She does not wander away into the void inane. She has nothing to do with questions of primal origin nor of ultimate destinies; not because they are unimportant questions, or insoluble, but because they transcend her instruments and her methods. She leaves them to philosophy, which proceeds not by demonstration and proof but by insight, by intuition and by moral reasoning; or she leaves them to revelation, in whose supernal light alone they can be properly illuminated and fully seen."

To avoid being misled, a correction or two is here necessary, before considering Mr. Godwin's main position. He says that science is exact, which is quite true of the "exact sciences," but is not true of all science. It is not true of those in which the phenomena do not admit of precise measurement, such as biology, psychology, and sociology, which are nevertheless clear and certain in their truths and as strictly sciences as any other. He says that science deals with "facts and the coördination of facts only." But facts can neither be determined nor coördinated except by the constant use of theories

and hypotheses. Science consists in the *interpretation* of facts, and this always begins with hypothetical conjecture; while the progress of science is nothing else than the growth of hypothesis and of theory by which facts are put in their proper relations.

Mr. Godwin avers that science has nothing to do with questions of "primal origin," by which he means, as we gather from a passage to be directly quoted, questions of the origin of the universe, the origin of our earth, the origin of plants and animals, the origin of man and his institutions. This is certainly an extraordinary statement to put forth to the scientific men of the present day. And that a great problem of Nature which is soluble, is yet not a problem of science, but belongs to a method which "proceeds not by demonstration and proof," is a statement that will be equally surprising. As for the method of "insight," "intuition," "moral reasoning," and "revelation," it had been tried on the phenomena of Nature for thousands of years, and it was exactly because it had broken down that the method of science arose. The order of the universe has been discovered by demanding "demonstration and proof;" but on what ground is it assumed that the problem of the *present* operations of the universe is of a different nature from the problem of its *past* operations? The order of Nature is one and continuous, and the same method which has given us a knowledge of its present workings can alone be competent to give us the knowledge of its past workings. Science is the coördination of facts, that is, putting them in order, but they must be coördinated in their sequences as well as in their coexistences—in time as well as in space. Nor is it any more possible to study the present in Nature, without going back to the past which has created it, than it is to do the same thing in political affairs. It is now well recognized that our knowledge of existing things is profoundly dependent upon our knowledge of the way they have been produced. The present phase of astronomical science embraces the problem of the formation of the solar and stellar systems. What is geology but a history of the formation of the earth? Zoology has been revolutionized by modern embryological studies. The psychological point of view is now that of the development of mind. Philology has become a science through the study of lingual origins; and sociological science has at its foundation the problem of the origin and growth of social activities and organizations. Questions of origin, of derivation, and of transformations in time, are, in fact, the supreme characteristics of the science of the nineteenth century.

Mr. Godwin forbids it. He might as well forbid the flow of the Gulf Stream; it cannot be arrested till the study of cause and effect is ruled out of the scientific court as an illegitimate procedure. The study of origins is the highest issue of ages of scientific preparation, and the ripening of science into an authentic philosophy.

Of Mr. Godwin's three or four examples of illegitimate science, here is one. He says: "Then there is another of these outside teachers of science, but this one is entitled to the highest respect—though I think he rides a hobby beyond the capacity of the creature to carry—who contrives a vast process of cosmic evolutions, who tells us that a great while ago—ten thousand years—no, a hundred million of millions of millions of years ago—a nebulous gas was diffused through the immensity of space, which first twisted itself into a solar system, then into a world, then into layers of mineral strata, then into vegetable spirales, into animal motions, into human vortices called societies, into iliads, parthenons, and Shakespeares, and at last into a grand philosophy of evolution—the crown and consummation of the

whole; which may all be true, though the birth strikes me as hardly worthy of so long and so tremendous a parturition."

Mr. Godwin declares that the doctrine of Evolution, of which he seems to have a very tortuous conception, is an instance of illegitimate science. The nebular hypothesis is its first and remotest "twist," and so Kant, Laplace, Herschel, Huggins, and a multitude of other astronomers who have contributed to its establishment are to be pitched over the enclosure as pseudo-scientists! If the reader will glance at the excellent paper of Prof. Leconte in the preceding pages, on the Nebular Hypothesis, he will quickly see what Mr. Godwin's opinion in this matter is worth.

But the foregoing passage has a further significance; it gives an interesting clew to Mr. Godwin's estimate of the value of the universe. It is not worth production by so tedious a process as that of Evolution; but, if got up in six days—indefinite periods being excluded—Mr. Godwin would probably allow that it is worth cost. Estimates of the natural world will of course vary with the knowledge of it. The first valuation was made in times of blank ignorance of Nature, and still harmonizes with that state of mind. Yet Mr. Godwin's position evinces progress, because in the pre-scientific ages Nature was not only despised as worthless, but hated as worse than worthless. The whole scheme was regarded as under a divine curse, and its students were put into prison and punished in various ways. We are past all that now, and Nature is considered as of some interest and fit enough to be studied by those who like it—if they will consent to have bits in their mouths and be kept within suitable bounds. There has been progress, because the dispensation of hate has been succeeded by that of indifference; but still the devotion of men of science to the study of Nature is a popular puzzle. It is not yet looked upon as the highest occupation of the human mind to extend our knowledge of the order of things around us. On the part of classes still called educated, there survives an ill-concealed contempt for the mental pursuits of mere collectors, observers, and experimenters. It is not now so bad as when in England Lady Glanville's will was attempted to be set aside on the ground of lunacy, evinced by no other evidence than a fondness for collecting insects; yet enthusiastic naturalists who ransack field and forest, mountain and sea, are still regarded as a class apart—as eccentric objects of curiosity, not to be compared in dignity with the students of art, literature, and metaphysics. So much of the old spirit continues that, as objects of thought and in the education of to-day, the works of man are ranked as superior to the works of God. Nor is it by any means considered so very desirable to know all about Nature. Large numbers of the cultivators of sentimental literature still protest that, if the world were once understood, it would no longer be worth living in. The heads of college-bred people are still filled with old childish fictions which are fondly cherished, and science, because it would clear away the mountains of this rubbish, in which the seekers after a liberal education are still made to delve, is dreaded as a desolating agency that would bereave us of all that is most refining and ennobling in culture. In his speech, Mr. Godwin goes off with double objurgation, as follows: "'Great God!' as Wordsworth says—

> . . . . "'Great God! I'd rather be
> A pagan suckled on a creed outworn;
> So might I, standing on this pleasant lea,
> Have glimpses that would make me less forlorn.
> Have sight of Proteus rising from the sea,
> Or hear old Triton blow his wreathèd horn.'"

Now, this may be all very well for callow sophomores; but when old fel-

lows, who ought to have been weaned from this pagan nonsense long ago, take to whining about their forlornness, with nothing remaining but God's universe, the case becomes pitiable. This is the second time that Prof. Tyndall has been gravely told across the table in New York by after-dinner orators that they would go back to heathenism rather than accept the science that his presence suggested—a striking comment on the value which these defenders of the faith attach to the religion of civilization. But let people be suckled where they please; as for our own spiritual lactation we prefer to get it from the revelations of modern science rather than from the Jack-and-a-Beanstalk tomfooleries of pagan mythology.

No! the alarm-bell is rung at the progress of science in the present age to but little purpose. The worth of the universe must rise as its grandeurs are comprehended, and our joy in its harmony and beauty will be heightened the more deeply it is understood.

"I grieve not that ripe knowledge takes away
The charm that Nature to my childhood wore,
For with the insight cometh day by day
A greater bliss than wonder was before."

Nor are religious considerations to be invoked to deter men of science from their exalted work, for the single-minded pursuit of truth is an intrinsically religious act. No limits are to be tolerated but those imposed by Nature herself, and up to those limits the work must be pressed as a sacred duty. For, if, as we believe, science is but a record of the Divine operations in matter, there is devoutness in scientific investigation, and to push it to the farthest possible boundaries becomes a matter of clear religious obligation.

THE article of Dr. Barnard, characterizing our educational system, and the brief statement of Prof. Agassiz's opinion in regard to New-England education, both of which will be found elsewhere in our pages, are commended to the very special attention of the burning advocates of compulsory education. According to these, all that our educational system lacks of perfection is a suitable appendage of policemen and constables to drive everybody into the school-houses, that they may be compelled to participate in its blessings. In their view, the only difficulty remaining is a defective will, and a perverse and contumacious spirit, which can only be dealt with by law-warrants and bludgeons. In so far as compulsory education is merely a kind of street-cleaning, a scraping together of refuse and vagabond children in places where something can be done to humanize them, it may be admissible; but there are very serious grounds of protest against coercion being carried farther. If our so-called educational system be defective to its very roots, a total inversion of the method of Nature, and a violation of the constitution of the mind, as Dr. Barnard declares, or if it be a crude vestige of old mediæval ignorance and stupidity, as Prof. Agassiz maintains, there is evidently a good deal to do before police-officers can be properly invoked to force it down people's throats. The logic, of course, is short from the establishment of State education, and its maintenance by compulsory taxation, to its enforcement upon everybody by legal coercion. But State education has its evils, and not the least of them is that it gets the benefit of our idolatry of government and the blind admiration of the "institutions of our country," which are believed to be the most perfect under the sun. But "first be sure you are right, and *then* go ahead" is a golden motto, and, if applied in this case, will postpone for some time the crusade of the coercionists. As long as our school-system is open to such indictments as those of Messrs.

Barnard and Agassiz, which will be sustained by every intelligent critic who looks into it, we submit that the question of compulsion is premature; if any system is to be enforced, let it be a rational one.

LITERARY NOTICES.

KEY TO NORTH AMERICAN BIRDS, containing a Concise Account of every Species of Living and Fossil Bird at present known upon the Continent north of the Mexican and United States Boundary. Illustrated by Six Steel Plates and upward of 250 Woodcuts. By ELLIOTT COUES, Assistant Surgeon United States Army. Boston: Estes & Lauriat. New York: Dodd & Mead, 1872.

THIS exhaustive and beautifully-executed folio comes to us as an exponent of the present state of American ornithological science. The position of Dr. Coues as a naturalist is a guarantee of the character of his work. He lays under contribution the latest results, having been assisted by various eminent gentlemen, while a large part of the volume consists of his own original observations. While the work is attractive to all who care for this fascinating subject, the author has nevertheless aimed at strict scientific accuracy in his statements. At the outset he puts the question, "What is a bird?" and most people would think the answer very simple, but in such matters most people are apt, unhappily, to be mistaken. How loose and insufficient the common notion would be as compared with the conception of science, may be shown by quoting the answer that Dr. Coues gives to his own question: "A bird is an air-breathing, egg-laying, warm-blooded, feathered vertebrate, with two limbs (legs) for walking or swimming, two limbs (wings) for flying or swimming, fixed lungs in a cavity communicating with other air-cavities, and one outlet of genito-urinary and digestive organs; with (*negative characters*) no teats, no teeth, no fleshy lips, no external fleshy ears, no (perfect) epiglottis nor diaphragm; no bladder, no scrotum, no corpus callosum; and with the following collateral characters, mostly shared by more or fewer other animals: under jaw hinged with the rest of the skull by means of an interposed movable bone, that is also movably jointed with two bones of the upper jaw; head jointed with neck by only one hinge; shoulder-joints connected with each other by a curved bone, the clavicle (with rare exceptions), and with the breast-bone by a straight, stout bone, the coracoid; ribs all bony, most of them jointed in the middle as well as with back-bone and breast-bone, and having offsets; less than three *separate* wrist and hand bones; two fingers, of one or two bones; head of thigh-bone hinged in a ring, not in a cup; one of the two leg-bones not forming the ankle-joint; no *separate* ankle-bones; less than three *separate* foot-bones; two to four toes, of two to five bones, always ending in claws; both jaws horny-sheathed and nostrils in the upper one; feet and toes (when not feathered) horny-sheathed; three eyelids; eyeball with hard plates in it, eight muscles on it, and a peculiar vascular organ inside; two larynges, or 'Adam's apples;' two bronchi; two lungs, perforated to send air into various air-sacs and even the inside of bones; four-chambered heart, with perfect double-blood circulation; tongue with several bones; two or three stomachs; one liver, forked to receive the heart in its cleft; gall-bladder or none; more or less diffuse pancreas or 'sweet-bread;' a spleen; intestines of much the same size throughout; cæca or none; two lobulated, fixed kidneys; two testicles fixed in the small of the back, and subject to periodical enlargement and decrease; one functional ovary and oviduct; outlets of these last three organs in an enlargement at end of intestine, and their products, with refuse of digestion, all discharged through a common orifice. But of all these, and other characters that come under the head of description rather than of definition, one is peculiarly characteristic of birds; for every bird has FEATHERS, and no other animal has feathers"

MYSTERIES OF THE VOICE AND EAR. By Prof. O. N. ROOD, of Columbia College. Chatfield & Co., New Haven. University Series.

THIS pamphlet is one of the most admirable expositions of its subject that we have ever read. Prof. Rood is one of our first physicists, the author of many valuable

researches, and his essay is thoroughly up in the latest results of acoustics and the physiology of sound, while his lecture is not only crowded with interesting scientific facts, but it is written in a remarkably clear and familiar style; the only difficulty being, that there is not half enough of it. He closes with the following suggestive passage: "If you were to tell a thoughtful man, who happened to be quite ignorant of the mechanism and action of the voice, that there were living beings who endeavored to express their wishes, thoughts, and feelings, merely by the aid of mechanical vibrations, thus causing the particles of air to swing like invisible pendulums backward and forward in certain ways, your listener would be impressed by the poverty of the device, and would too hastily conclude that only a few of the simplest and rudest ideas could possibly find expression by the aid of a contrivance so clumsy. He would tell you it was conceivable, perhaps, that, by appropriate use of vibrations, the idea of joy, or rage, or fear, or possibly of hunger, might be imperfectly expressed, with a few others of like character, but that to expect more would be visionary. He would urge that all vibrations were necessarily so similar in general character, that it would be impossible to communicate to them the stamp of thought or feeling. And yet how wonderfully each one of us employs just such vibrations, and, with a skill which seems truly superhuman, impresses upon and commits to them an infinite variety of thoughts, feelings, and ideas, which at times we pour forth in torrents that seem inexhaustible; the vastness of the result attained, the poverty of the means, are utterly overwhelming!

"Think, also, for a moment, of that gift by which we read the stories written on the invisible waves of the air; how we instantly interpret and disentangle their complexities, as they roll in toward us, thousands in a second, with the velocity of rifle-bullets. The powers to hear and speak are gifts which, from purely physical and mathematical stand-points, are absolutely magnificent! And we the possessors of such powers! Is it conceivable that they have been bestowed on us only to be used as at present? Do they not point to a future for our race when they will be employed in a manner which better accords with their inexpressible richness and grandeur?"

MYTHS AND MYTH-MAKERS. Old Tales and Superstitions interpreted by Comparative Mythology. By JOHN FISKE, M. A., of Harvard University. Boston: J. R. Osgood & Co.

MR. FISKE has given us a book, which is at once sensible and attractive, on a subject about which much is written that is crotchety or tedious. He has devoted himself to the study of myths without allowing them to impair his judgment on matters of fact, and he has become familiar with myth-makers without adopting their hazy views and ambiguous expressions; and so, although we may not entirely agree with him on every point, yet we can heartily recommend his unpretending but instructive volume to the large class of readers who are interested in the subjects with which he deals. It does not claim to be a work of scientific arrangement and close reasoning. Its author, indeed, speaks of it, in his modest preface, as a "somewhat rambling and unsystematic series of papers;" but to the general public it will not, on that account, prove less agreeable.

Mr. Fiske disclaims any attempt "to review, otherwise than incidentally, the works of Grimm, Müller, Kuhn, Bréal, Dasent, and Tylor," nor does he claim "to have added any thing of consequence, save now and then some bit of explanatory comment, to the results obtained by the labor of these scholars;" but it has been his aim, he says, "to present these results in such a way as to awaken general interest in them." This aim he seems to us to have fully attained; and we shall be surprised if his book does not do good service in enlisting the sympathies of a large number of readers in behalf of a science which some critics find it more easy to deride than to comprehend. Mr. Fiske's volume comprises seven chapters, which seem to have been originally as many reviews of various works on mythology and animism. Beginning with "The Origins of Folk-lore," he traces home some of the most widely-spread of the pseudo-historic stories, such as those of William Tell, and of Llewellyn and Gellert, as well as a few of the Popular Tales which have

caught the fancy of most nations, such as that of "The Master Thief," or "The Giant who had no Heart in his Body." His conclusions, which we are not altogether inclined to accept, are, "that the Tell myth was known, in its general features, to our Aryan ancestors before ever they left their primitive dwelling-place in Central Asia;" and that the Popular Tales

"have been handed down from parent to child for more than a hundred generations; that the primitive Aryan cottager, as he took his evening meal of *yava* and sipped his fermented mead, listened with his children to the stories of Boots, and Cinderella, and the Master Thief, in the days when the squat Laplander was master of Europe, and the dark-skinned Sudra was as yet unmolested in the Punjab."

This is Dr. Dasent's view, and, to a certain extent, that of a still greater authority, Prof. Max Müller. For our part, we are rather of the opinion of Prof. Benfy and his school, and are inclined to recognize, in at least most of the longer and more dramatic of our fireside and nursery romances, mere echoes of tales told long ago by Indian story-tellers. But Mr. Fiske's creed is likely to be the more popular of the two, and he has defined and justified it in a manner which all must praise. His remarks on the vexed question of the Homeric poems can scarcely offend even those critics who are least inclined to identify Athênê and Helen with the dawn or any other atmospheric phenomenon; for he is fully conscious of a truth which has been overlooked by the more enthusiastic writers on the subject—that tales and traditions in their present forms are seldom capable of being straightway resolved into perfect Nature-myths, and that in many cases they have been moulded into their present forms by composers or adapters who were perfectly innocent of mythical meaning—that, as he justly remarks:

"The primitive meaning of a myth fades away as inevitably as the primitive meaning of a word or phrase; and the rabbins who told of a worm which shatters rocks no more thought of the writhing thunder-bolts, than the modern reader thinks of oyster-shells when he sees the word *ostracism*, or consciously breathes a prayer as he writes the phrase *good-by*."

The second chapter of Mr. Fiske's book is devoted to "The Descent of Fire," and seems to have been originally intended as a review of Prof. Kuhn's admirable essay on that subject, or of Mr. Kelly's "Indo-European Folk-lore," a book based upon the works of Kuhn, Grimm, and Mannhardt. The third chapter is to a great extent borrowed from Mr. Baring-Gould's writings on "Werewolves and Swan-Maidens," and is rather inferior to the rest of the book in the matter of critical rejection. It is followed by a chapter on "Light and Darkness," which contains several interesting studies of the numerous evil spirits to which the fancy of different peoples has given rise, and especially of "the mediæval conception of the devil." The fifth chapter, on "The Myths of the Barbaric World," will probably prove the most novel and amusing of all to the general reader, but it makes no pretence of offering any thing that is new to students who are acquainted with Mr. Tylor's works, and with those less known, but valuable books, Brinton's "Myths of the New World," Callaway's "Zulu Nursery Tales," and Bleek's "Hottentot Fables."—*Athenæum.*

COFFEE: Its History, Cultivation, and Uses. By ROBERT HEWITT, Jr. New York: D. Appleton & Co., 1872.

THIS claims to be the first book in the language exclusively on the subject of coffee, of the history, cultivation, and uses, of which it gives much information. The introduction of coffee into the great capitals of Europe, and the history of their *cafés*, as well as the old coffee-houses in New York, are described in several entertaining pages. Java and South America are the two principal coffee-producing countries, the former furnishing the most highly-prized bean, which is unequalled for delicacy of aroma and the mild oily richness of the beverage. The latter, however, furnishes the most important staple, and its influence as a branch of industry and an element of commerce is shown by the fact that no less than 244,000,000 pounds of Rio coffee were consumed in the United States in a single year, which makes us the largest coffee-consuming nation in the world. Numerous methods of preparing coffee are mentioned in the volume,

the best contrivance being stated as the following: It consists of a double coffee-pot, the inner one, containing the coffee and water, being completely surrounded by steam which is generated in a pan or receiver, over which is placed the coffee-pot. In this way all the rich, oily aromas are thoroughly extracted by the action of steam-heat surrounding all parts of the inner vessel. The coffee can never boil, and the result is a beverage more perfect than any percolating, boiling, or straining process has ever produced.

A chapter is devoted to the analysis and adulterations of coffee, and the volume contains a beautiful colored frontispiece representing the coffee-plant, and a map showing its geographical distribution. The work is very neatly gotten up.

THE TEN LAWS OF HEALTH; OR, HOW DISEASE IS PRODUCED AND CAN BE PREVENTED. By J. R. BLACK, M. D. Philadelphia: J. B. Lippincott & Co., 1872.

IN another part of this number of the MONTHLY, the reader will find an interesting paper from Dr. Black, on "Applied Sanitary Science," in which, after pointing out some of the more formidable difficulties obstructing a general application of sanitary rules, he urges, as the only effective means of making these rules universally available, that every intelligent member of the community master the leading facts and principles of the subject. In this way his eyes will be opened to the dangers which surround him, and the knowledge necessary to their avoidance or removal will also be at hand for practical use. To this important educational work the Book before us is a valuable contribution. The author begins by enforcing the proposition, with which most intelligent physicians will doubtless agree, that diseases are, as a rule, preventible; that man brings them upon himself through ignorance and carelessness, and that most of them may be avoided by conforming to certain well-ascertained laws of health. These laws he ranges under ten heads, in the order of their importance, and then considers each in a threefold manner: the various ways in which it is commonly violated are first pointed out; the results which follow are next indicated; and, lastly, comes a description of the ways and means necessary to its proper observance. With some slight exceptions, the matter of the book is eminently sound, and its precepts safe to follow, while the style is clear and vigorous, qualities which, united with the excellence of its mechanical get-up, admirably fit it for popular reading.

ADMINISTRATION OF JUSTICE UNDER MILITARY AND MARTIAL LAW. By CHARLES M. CLODE. London: Murray. New York: Scribner, 1872.

A ROYAL commission in England, some time since, expressed a desire for some such work as the present, and the British War Department have made an acquaintance with military law an essential condition of promotion in the army. It is therefore plain that this work meets a want in England; and, as the United States Army is governed by a code remodelled on the basis of the British Mutiny Act, military men on this side of the Atlantic will probably find these pages valuable for reference.

LECTURES ON LIGHT. Delivered in the United States, in the Winter of 1872–'73. By Prof. JOHN TYNDALL, LL. D., F. R. S. 196 pages. D. Appleton & Co.

IN his address at the farewell banquet, Prof. Tyndall said: "On quitting England, I had no intention of publishing the lectures I have given here, and, except a fragment or two, they were wholly unwritten when I arrived in this city. Since that time, besides lecturing in New York, Brooklyn, and New Haven, the lectures have been written out. No doubt many evidences of the rapidity of their production will appear; but I thought it due to those who listened to them with such unwavering attention, as also to those who wished to hear them, but were unable to do so, to leave them behind me in an authentic form." Many thousands who listened to these lectures, and many more thousands who did not, will be grateful to Prof. Tyndall for having written them out so fully for general perusal. Accompanied as they are with numerous illustrations of apparatus and experiments, and written in the author's vivid and graphic way, they will interest the reader almost as much as they did those who heard them.

These lectures were undoubtedly pre-

pared with rapidity, but the reader, we think, will find few traces of it. They were written out with extreme care, and, in vividness of description, felicity of illustration, and transparent clearness, they fall below nothing that this author has given us before. The text is accompanied with numerous neatly-executed cuts of apparatus and experiments, which will aid the thousands who heard the lectures to recall the scenes and circumstances of their delivery, while other thousands, who saved their time and money by absence, will get the result of the professor's teachings in a form by no means unsatisfactory.

Prof. Tyndall came to this country, not to have a "good time," but to do hard work; and he worked hard, not to profit himself, but to promote the interests of science, which he has most at heart. And he not only gave his talent, his exertion, and six months of his precious time, to this object, but he left all the profits of the enterprise to be used for promoting scientific education.

Prof. Tyndall's receipts from his lectures in the several cities were as follows:

Boston, six lectures	$1,500
Philadelphia, six lectures	3,000
Baltimore, three lectures	1,000
Washington, six lectures	2,000
New York, six lectures	8,500
Brooklyn, six lectures	6,100
New Haven, two lectures	1,000
Total	$23,100

Of this amount, the surplus above expenses, amounting to upward of $13,000, was conveyed, by an article of trust, to the charge of a committee, of which Prof. Joseph Henry is chairman, and which is authorized to expend the interest in aid of students who devote themselves to original researches. This is certainly a noble example, and deserves to be emulated.

The "Proceedings of the Farewell Banquet to Prof. Tyndall" are now in press, and are soon to be published in a pamphlet. It will contain letters from the scientific men throughout the country, and all the speeches delivered on the occasion, revised by their authors.

ARRANGEMENTS have been made by the firm of Holt & Williams to furnish the *Fortnightly Review* to American subscribers at the reduced price of $6.00 a year, or 50 cents a number. This able periodical was projected and established by Mr. George H. Lewes, some ten years ago, and was at first, as its name implies, published once a fortnight. It was modelled on the plan of the *Revue des Deux Mondes*, the leading French periodical, which is issued every two weeks. After three or four years, however, Mr. Lewes withdrew from his management, and it was changed to a monthly, under the editorship of Mr. Morley, author of the excellent papers on Voltaire and Rousseau. The *Fortnightly* is the chief organ of the Positivist writers in England, such as Mill, Harrison, Brydges, and contains much able discussion of radical politics and advanced philosophy.

ANNALS OF BEE CULTURE, for 1872, D. L. ADAIR, Editor (published by John P. Morton, Louisville, Ky.), contains twenty-two papers by well-known authorities on matters relating to the apiary. The opening article, "The Genesis of the Honey-Bee," by the editor, will well repay an attentive perusal.

BOOKS RECEIVED.

Manual of Paleontology. By Henry Alleyne Nicholson. Edinburgh, 1872. Blackwood.

Caliban: the Missing Link. By Daniel Wilson, LL. D. London and New York: Macmillan.

Modern Diabolism; Commonly called Modern Spiritualism. With New Theories of Light, Heat, etc. By M. J. Williamson. New York, 1873. James Miller. (Not worth reading.)

Arrangement of the Families of Fishes (Smithsonian Miscellaneous Collections, 247). By Theodore Gill, M. D., Ph. D. Washington, 1872.

Arrangement of the Families of Mammals. Same author.

Traction Engines and Steam Road-rollers. By Prof. R. H. Thurston, of Stevens Institute of Technology.

Lecture before the Burlington Library Association, by Philip Harvey, M. D.

Birds of North America.

What Physiological Value has Phos-

phorus as an Original Element? By Samuel R. Percy, M. D. Philadelphia: Collins, 705 Jayne Street, 1872.

Report of the Committee on Climatology, etc., of Arkansas. By Geo. W. Lawrence, M. D. (Same publisher.)

Twenty-first Annual Report of the Regents of the University of the State of New York, on State Cabinet of Natural History, etc. Albany, 1871.

Researches in Actino-Chemistry. Memoir Second. By John W. Draper, M. D., LL. D.

Australian Kinship. By Lewis H. Morgan.

Second Annual Report of the Board of Commissioners of the Department of Public Parks (New York City). 1872.

Mysteries of the Voice and Ear. By Prof. O. N. Rood. New Haven: Chatfield, 1873.

MISCELLANY.

The Selective Power of Plants.

SHEFFIELD SCIENTIFIC SCHOOL, NEW HAVEN, CONN., *Feb.* 25, 1873.

Editor Popular Science Monthly.

DEAR SIR: In his interesting article on "Spontaneous Movements in Plants," printed in your January number, Dr. A. W. Bennett remarks, page 284, that "the selective power of plants, in absorbing from the soil a larger portion of those ingredients which are required for the formation or healthy life of their tissues, is an absolutely unexplained phenomenon." Dr. Bennett says further, "A striking instance of the liability to consider a mere statement of an obscure law in other terms as an explanation of that law, occurs in an admirable treatise on the growth of plants — Johnson's 'How Crops Grow.'" Then follows the subjoined quotation from my book (the italics are Dr. Bennett's): "The cereals *are able to dispose* of silica by giving it a place in the cuticular cells: the leguminous crops, on the other hand, *cannot remove it* from their juices; the latter remain saturated, and thus further diffusion of silica from without becomes impossible, except as room is made by new growth. It is in this way that we have *a rational and adequate* explanation of the selective power of the plant." Dr. Bennett adds: "The 'rational and adequate explanation' seems to me, on the contrary, to be merely a restatement of the selective power of the tissues in other terms. Because the tissues want the silica, is no explanation of how they get it."

Very possibly, Dr. Bennett holds me at a disadvantage as the matter thus stands, but I am, in fact, very seriously misrepresented in the last sentence of his quotation from "How Crops Grow." On page 363 of the American edition, the reader may see that the period which concludes Dr. Bennett's quotation should be a comma, and that the sentence, as I wrote it, first comes to a conclusion after an important qualifying clause, and reads, entire, as follows: "It is in this way that we have a rational and adequate explanation of the selective power of the plant *as manifested in its deportment toward the medium that invests its roots.*"

It appears that Dr. Bennett has inadvertently confused two quite distinct things. He asserts, at first, that "the absolutely unexplained phenomenon" is "the selective power of plants in absorbing from the soil those ingredients which are required for their tissues." But, afterward, he declares my "explanation" to be "merely a restatement of the selective power *of the tissues.*" Obviously, the selective power of the plant, as manifested toward the medium that invests its roots, is one thing, and the selective power of the tissues toward the substances dissolved in the cell-juices is, or in many cases may be, another. The former is what I offered a rational and adequate explanation of. The latter I have not ventured to attempt to explain. The former is explained by being coördinated with the well-ascertained facts of "diffusion" and "osmose," and referred to established, if not fully-developed, physical laws. The latter belongs to the yet very obscure phenomena of chemism, which are only known to us imperfectly in some of their results, and whose inner nature the recent amazing progress of organic chemistry has hardly begun to enable us to speculate upon with any satisfactory degree of probability.

Dr. Bennett writes of silica as one "of

those ingredients which are required for the formation or healthy life" of the plant-tissues. In "How Crops Grow," the evidence is given which forces us to the conclusion that silica is unessential to the growth and perfect development not only of leguminous plants, but of all the various cereals, although the latter, when they grow in the soil, do contain 2.5 per cent., more or less, of this substance in their foliage. If silica be taken up by legumes and by corn-crops which are able to grow to perfection of parts and fulness of dimensions in its absence, then, certainly, "because the tissues *want* silica is no explanation of how they get it;" but saturation of the cell-juices does explain how a limit is put to the influx of this body into the plant from the soil.

S. W. Johnson.

Probable Cause of Boiler-Explosions.—Some six years ago, Mr. W. F. Barrett, F. C. S., observed that a red-hot ball of copper, on being immersed in a light solution of soap in water, entered the liquid without hissing or visible generation of steam. In a paper read before the British Association, he tells of sundry experiments made with a view to investigate this phenomenon, and thinks that it probably accounts for many otherwise unaccountable explosions of steam-boilers. After experimenting with sundry red-hot metals in soap-water, he tried water without soap; but then the hissing was loud, and the evolution of steam copious. He next dissolved in water several soluble substances, and found that albumen, glycerine, and organic liquids in general, facilitate the acquisition by water of the spheroidal shape, probably by increasing its cohesion, while bodies such as ammonia, which yield vapor readily, have the same effect, though in not so marked a degree. Oil, whether shaken up or floating on the water, has the same effect as soap. When the red-hot ball is lowered into the liquid, to a depth of a foot or more, it is seen to be surrounded by a shell of vapor, bounded by an envelop resembling burnished silver. As the ball cools, the shell grows thinner, and finally collapses. This is followed by a report, and volumes of steam are emitted. The author adds: "I have heard that traces of oil get into the boilers of steam-engines, and there can be no doubt that dissolved organic matter often finds its way in. If in any way we increase the intensity of the water, we render it possible for a corroded boiler to give way under the pressure of the steam suddenly generated in the way I have indicated."

Practical Application of Singing Flames.—The "singing flame," which at first view might seem to be merely a curious phenomenon, is found to be, in fact, a discovery of very high importance for science and the useful arts. One of the latest applications of this principle is that made by Dr. A. K. Irvine, of the British Iron and Steel Institute, who makes use of the singing flame in the construction of a safety-lamp for mines. If an explosive mixture of inflammable gas and air be passed through and ignited on the surface of a disk of wire gauze too fine to suffer the flame to traverse it, and then surrounded by a chimney, to prevent air from entering, save through the gauze, the flame vibrates, and, the vibration being communicated to the ascending gases, produces a sound varying in pitch and intensity according to the height and calibre of the chimney. A lamp constructed on this principle will give timely warning to the miner whenever the atmosphere and the fire-damp are coming together in the proportions requisite for an explosion.

Science in the Household.—The application of science to the affairs of the household, both in the shape of improved processes and the introduction of labor-saving appliances, has already gone sufficiently far to warrant the expectation that from this quarter there will eventually come a solution of the problem of rational house-keeping, when the family will be largely rid of the annoyances incident to a state of dependence on incompetent and wasteful hirelings, and master of its own internal economy. Already the sewing-machine has wrought a revolution in the clothing department, which leaves scarcely a trace of its former wearisome tasks. The washing-machine and wringer, aided by various detergent preparations, have in like manner greatly lightened the work of the laundry, making the destructive and exhausting labor

of rubbing a useless waste of power. And now, as the latest and most important addition to the resources of the house-keeper, we have a device which, going under the name of the "Warren Cooker," accomplishes an even greater reduction in the labor, expense, and care of the culinary department of the household.

This implement was but recently introduced into this country, and, though widely commended, is comparatively unknown; we cannot, therefore, do our readers a better service than to give them a brief account of its advantages. The article is an application of the principle that cooking is best done at a low, uniform heat, or a heat that, in the case of meats, will neither coagulate their juices nor harden their fibre. By Warren's plan both meat and vegetables are cooked at the same time, though in separate compartments and in different ways. When the "Cooker" is in operation, the meat is enclosed in a tight chamber, the bottom of which rests in boiling water, while a large portion of the sides is surrounded by steam, the remaining or upper portion of the sides being exposed to the outer air. No water or steam is permitted to enter the chamber, which, by the above-described arrangement, is kept at a uniform temperature of about 210° Fahr. The juices of the meat, and consequently its flavor, are thus wholly retained without dilution or impairment, and at the end of the process both fibre and juices are left in a condition most favorable to the work of digestion, none of the hardness or stringiness of baked or roasted meats being in the least degree perceptible.

Vegetables are cooked by steam, which in its exit is made to traverse a chamber divided into compartments for the reception of different sorts. Dumplings, or any thing else permitting the direct contact of steam, may also be cooked in this part of the apparatus.

We have had the implement in almost daily use for upward of six months, cooking with it the meat, fish, and poultry, ordinarily employed for the table, and its general performance has been in the highest degree satisfactory. It saves all round, and might very appropriately have been named the "Economical Cooker." Compact and simple in arrangement, it is easily and quickly got into operation. Unable to go wrong when once properly started, it does away with the worry and care incident to ordinary cooking. Run by any contrivance that will boil water, it makes possible a great saving of fuel. Cooking the meat in a closed pot, without access of either water or steam, it saves over the old way a large percentage of material; and, always turning out an evenly-cooked, juicy, and never overdone joint, it above all saves the feelings of the entire family.

To this strong indorsement of the implement, it is our duty to add a word of caution, for the benefit of those who are just commencing its use. The circulars of the manufacturer state the time per pound required for cooking various meats. Rigidly adhering to these directions when we first began to use the "Cooker," underdone dinners were the frequent result; and it was soon learned that from three to five minutes additional per pound were required to make the process complete.

Not the least of the advantages that will follow the general adoption of this mode of cooking will be, the encouragement of simplicity in the preparation of food; for, inasmuch as the contrivance preseves the natural flavor of the articles cooked in it, there will be no need of adding all sorts of rich and indigestible sauces to replace the losses which occur in cooking by the methods now commonly employed.

Venomous Spiders in New Zealand.—Until recently it was supposed that New Zealand contained no venomous reptiles or noxious animals of any kind, and it was only so late as the year 1856 that the first scientific notice appeared of a poisonous spider, a native of that country. This notice was communicated to the British Linnæan society by Dr. Ralph, and contained a brief description of the katipo (*night-stinger*), giving an account of its nesting habits and of the potency of its sting. A writer in the *Field*, who has closely studied this animal in its native habitat, cites numerous instances showing that the katipo's bite is occasionally fatal, and invariably very painful. Like many other venomous creatures, the katipo is not aggressive, and stings only when he is molested and greatly

irritated; but, if merely touched with the finger, he will fold up his legs, and feign death. If again molested, the animal will try to escape, and will employ his sting only when driven to the wall. The katipo's nest is a perfect sphere, and the eggs about the size of mustard-seed. The changes undergone by this animal in its progress toward maturity are as follows: In the very young state its body is white, with two linear series of connected black spots, and an intermediate line of pale red; under parts brown; legs light brown, with black joints. In the next stage, the fore-part of the body is yellow, with two black "eye-spots," sides black, with transverse marks of yellowish white; dorsal stripe bright red, commencing higher up than in the adult, and with the edges serrated. At a more advanced age the stripe on the back is brighter, with a narrow border of yellow, and the thorax and legs are nearly black. In the fully adult condition, the female is very handsome in form and color. The body varies in size from that of a pigeon-shot to that of a small green pea; and the outspread legs even of the largest of these animals cover only a space of three-quarters of an inch. The thorax and body are black and shining, with a stripe of bright orange-red down the centre of the body. The male is considerably smaller, having the body blackish brown, with a faint-yellow line down the back.

Prof. Agassiz's Estimate of New-England Education.—The following significant paragraph is from the *Tribune:*

"Prof. Agassiz's speech before the Committee on Education at Boston, last week, was practical, impetuous, and a little impatient. His demand for a State appropriation for the benefit of the Cambridge Museum served as a text from which he drew a sermon, unpleasant, but not untrue nor unnecessary. He warmly expressed his disapproval of the existing system of popular education in America. Instead of using the rich and growing intellectual material of later years, he declared that our colleges teach chiefly the traditional learning of the middle ages. 'Harvard,' said the fiery professor, 'is not a university; it is only a tolerably well-organized high-school.' Nor is even this learning, in his eyes, the best of its kind; it is merely the dregs of scholarship. He brought up our grammar as an example, referring to it as no longer a living matter, but a reduction to formulas from which all the living spirit has fled. As for his darling, Natural Science, he contemplates mournfully the want of thoroughness with which its phenomena are taught in the common schools. The fault, he asserts, is that of the teachers, who have no sort of thorough knowledge in this direction, and who cannot get it from the normal schools, where instruction is given from text-books alone, and in the poorest possible manner. The schools of Massachusetts had round censure from the good professor, and very much it must have astonished the authorities of that great State, who are incessantly ready to fold their hands and go to heaven when they think of their 'superior' school system. Owing to the misplaced confidence which they have in it, the professor thinks that it might be easier to push a new course of education in a new State earlier than in New England."

Ancient Bavarian Agriculture.—The Historical Society of Munich has recently set on foot an investigation of the remains of ancient agriculture to be found in the neighborhood of that city, and in other parts of Bavaria. Garden-plots of an unknown antiquity have been discovered, many of them assuming the form of a parallelogram, with beds of equal length, breadth, and height; while others are in the form of a trapeze, with beds of very unequal length. Oftentimes wide and narrow beds alternate; and again beds are found side by side, the one being ten times the length of the other.

In height they vary from 1¼ to 3 feet or over, and the soil is scooped up out of the furrow and thrown up on the bed, uncovering the gravel. There is no trace of drains or water-courses dating from the period of these gardens, though water-courses of a later time are to be seen. In the middle of one of these agricultural districts is always found a free space where in all probability the people had their dwellings, although we find no trace of their abodes. If there ever were houses there, they must have been built of light material. Horseshoes are found at various depths in the soil. These

are of small dimensions, and so eaten away by rust that they evidently belong to a very remote period. A writer in the *Presse* is of opinion that these little farms date back some 2,000 years, and that then the climate of Bavaria was very moist; for such treatment of the soil in the present comparatively dry climate of that country would lead to the destruction of the crops by drought. It is a little curious that the writer makes no mention of any agricultural or other implements being found; but perhaps closer investigation will bring such objects to light.

Recent Meteorites in France and Italy.—Several members of the French Academy of Sciences have written for that body accounts of two or three meteoric masses lately seen to fall in France and Italy. On July 23d, at about half-past five, on a still afternoon, with clear sky, and the sun shining brightly, there was heard at Lancé (Loir-et-Cher) a violent report, succeeded by a rumbling. A "fiery lance" was observed by a land-owner of Lile-Bouchard to shoot across the sky with great swiftness. *En route* it divided into two meteors, which continued for some time to move parallel. At Tours they were also observed, and described as bottle-shaped, and of an orange color. One of these meteorites was found near Lancé by M. de Tastes. It weighed about 103 lbs., and had penetrated into the earth to a depth of 5 feet 9 inches. It broke to pieces on removal. The other meteorite was soon after found, some 7½ miles south of the first. It was of the same character as the first, but weighed only a few ounces and had penetrated about 20 inches. The large piece is of an unequal spheroidal shape, with rounded surface, and covered with a crust as if by fusion. The fracture is black, showing globular structure, and numerous small spheroidal grains. Here and there are small metallic grains, yellow in color. Specific gravity 3.80. In water it yielded a very small quantity of chloride of sodium. There is not a trace of salts of potash, nor any sulphates or hyposulphates. Dissolved in nitric acid, a silicate was found, consisting chiefly of magnesium and protoxide of iron. Spectrum analysis seemed to indicate the presence of copper; but there was no calcium, barium, or strontium. Carbon was absent, but, as usual, cobalt and nickel accompanied the iron. On the evening of August 8th, at 8 minutes past 11, a meteorite was seen at Rome, Velletri, and other places. But a more interesting one was observed by Padre Secchi at Rome, August 31st, at 5.15 A. M., mean time. A globe of fire was observed, well marked and a little red in color. Its progress was at first slow, but it gained speed, and left behind it a luminous train like a cloud lit up by the sun. On reaching its highest point, it suddenly expanded, and finally disappeared. Three or four minutes afterward a tremendous detonation was heard. It was like a mine-explosion, and was followed by a rolling sound, as of file-firing. A fragment of this meteor was picked up and found to be very ferruginous, hard, and covered with a crust. The extreme distances at which the meteorite was seen are 93 miles apart.

An Efficacious Disinfectant.—A writer in the *Chemical News* offers some useful hints on disinfectants, which may be of interest. After a long-continued series of experiments, he pronounces sulphate of aluminium and hydrochlorate of alumina very powerful disinfectants and antiseptics. Their solubility and harmlessness render their use admissible under all ordinary circumstances. The chloride and sulphate of iron have the same action as the above, and, further, they absorb the sulphuretted products of decomposition. For this reason these salts are the most efficacious of disinfectants. But there is one objection to their use, viz., that the iron would injure any vegetation with which the disinfected matter might come in contact. The writer recommends, as the best of all disinfectants, for general use, a solution containing hydrochlorate of alumina, with a small quantity of chloride of iron. The hydrochlorate will do all the work of a disinfectant and antiseptic, while the chloride will absorb the sulphuretted compounds.

Atmospheric Pressure and Vegetable Growth.—M. Bert, whose observations upon atmospheric pressure and animal life we have already noted, has been making experiments upon the influence of pressure on vegetation. From these it would appear

that temperature is not the only condition modifying vegetal growth at varying altitudes, but that varying degrees of atmospheric pressure have also a controlling influence in this respect. Some grains of wheat were sown in bell-glasses with all the conditions identical, save that the contents of one glass were subjected to the normal pressure of the atmosphere, those of another to two-thirds the ordinary atmospheric pressure, and those of a third to one-third the ordinary atmospheric pressure. The first grains sent forth shoots 20 centimetres (7 inches) long, the second 5 inches, and the third did not come up at all. Again, with a pressure of 5 atmospheres, the plants did not come up, the radicles only having been sent out, and on opening the vase a strong alcoholic odor was perceived, in place of the ordinary acetic odor of putrefying wheat. After a few days a mould made its appearance.

Electric Detonators for exploding Mines.—Two new electric detonators, for exploding mines, one for land and the other for marine service, have been introduced in England. The former consists of a tin tube filled with fulminating mercury, and having a head of beech-wood. The electric wires run through this head, being insulated by gutta-percha, and their extremities held apart. In the space between the ends of the wires, and in contact with the fulminating mercury, is loosely packed a little gun-cotton, which is ignited by an electric current. The marine detonator has also a tube of tin filled with fulminating mercury, as also a beech-wood head. From tip to tip of the wires extends a platinum wire $\frac{2}{10}$ inch long, and 0.003 inch thick, in a bed of loose gun-cotton. The electric current heats the platinum, thus igniting the gun-cotton and exploding the fulminant, which in turn explodes the powder.

Development of Vibrio-Life.—In the course of his very interesting experiments on protoplasmic life, Dr. Grace Calvert shows that a solution of albumen from a new-laid egg, in pure distilled water, does not develop protoplasmic life, when the atmosphere is shut out. If, however, it be exposed to the atmosphere for from 15 to 45 minutes, minute globular bodies will appear, which have an independent motion. The time required for these bodies to develop is proportioned to the surface exposed, as was shown by Dr. Calvert, who experimented with two portions of albumen, 400 grains each, one in a test-tube of three-fourths inch diameter, and the other in a test-glass showing a surface of liquid two inches in diameter to the atmosphere. In the tube, vibrios appeared after twelve days, but in the glass after five. With undistilled water, they appeared in the test-tube within 24 hours. Further, M. Pasteur having shown oxygen to be necessary to the life of the mucedines, Dr. Calvert shows that it is no less necessary to the existence of vibrios. To confirm this, he put into each of five glass bulbs a solution of albumen in water, the first being left in contact with the atmosphere 24 hours, and the ends of the tube then hermetically sealed about two inches on each side of the bulb. The other tubes were similarly closed, after passing oxygen, hydrogen, nitrogen, and carbonic acid, over the solutions. The tubes remained closed for 27 days, during which period the albumen in contact with oxygen was seen speedily to become turbid, and then that in contact with air, while the other three remained clear. The tubes were then broken, and it was found that those containing oxygen and common air held a large amount of vibrio-life, while those containing nitrogen, carbonic acid, and hydrogen, held but very small quantities; hydrogen least of all. Thus it was proved that oxygen is an essential element to the production of putrefactive vibrios. The transition from globular protoplasms, or monads, as he calls them, into vibrios, and their ultimate transformation into microzyma, is then described by Dr. Calvert. "A few hours after impregnation," says he, "the monads appear in the albumen, having a diameter of about $\frac{1}{17000}$ of an inch, and appear to form masses. Next, some of the monads are lengthened into vibrios, which have an independent motion, though still attached to the mass. As this motion prevails in this or in that direction, the mass is moved over the microscope-field. At last it is broken up, and soon each individual vibrio is seen rolling or swimming

about. Their size is now $\frac{1}{10000}$ of an inch, and they finally attain a length of $\frac{1}{6400}$ of an inch." These long vibrios are gradually changed into cells, which Dr. Calvert calls microzyms, the first step in transformation being their division into two independent bodies. An extremely faint line appears across the animalcule's centre, increasing in distinctness until the vibrio looks like two individuals joined together. Then they separate, acquiring each an independent existence. The parts again divide and subdivide, until they appear to be no more than cells endowed with great natatory power. In twelve months or so the vibrios disappear, being succeeded by microzyms, either in motion or at rest. If these latter be placed in a solution of fresh albumen, vibrios are abundantly developed, apparently because they have now all the circumstances favorable to their growth and reproduction.

Experiments on the Circulation of the Frog. — Certain drugs, such as digitalis, veratrum, and ergot, when taken into the system, are known to exert a powerful influence on the apparatus of circulation, and, on this account, are largely employed by physicians as medicinal agents. In order to learn something further of the manner in which they act, Dr. Boldt has been studying the effects produced by their active principles when thrown into the circulation of the frog. Curarized frogs had the intestines and mesentery exposed, so that the movement of the blood in these parts could be readily watched through the microscope. Twelve experiments with digitalin, injected hypodermically, showed that it produces a strong contraction of the peripheral vessels, which is followed by a marked slowing of the pulse, and this, if the dose be large enough, by laming of the heart, as shown by smallness, irregularity, and rapidity of the pulse, with a vibrating or undulating blood-stream; finally, after a short increase in rapidity, the pulse falls with great suddenness, and then, with general vaso-motor paralysis, the animal dies. Eleven experiments with veratrin showed that it directly paralyzes heart and arterial muscles, there being an immediate lowering of the pulse-frequency, the size and force of its wave, and an increase in the lumen of the vessels. Twelve experiments with ergotin resulted in a constant lowering of the pulse-rapidity, by both large and small doses, accompanied by peristaltic or wave-like contractions and expansions of the artery.

Paper Car-Wheels.—Car-wheels of paper, though universally admitted to be superior to those of iron or steel, have not been much used hitherto, owing to their high price. If, however, as is claimed, paper wheels are more durable than those of other materials, and if they do less injury to the tracks, besides being safer and more noiseless, it may in the end be found economical to employ them. The Connecticut River Railroad, as we learn from the *Iron Age*, is about to give these wheels a practical trial, having ordered a set of them for the forward truck of a locomotive. The process of manufacturing wheels of paper is as follows: A number of sheets of common straw-paper are compacted together under a pressure of 350 tons. The mass is then turned perfectly round, and the hub forced into a hole in the centre. The tire, which is of steel, has a bevel of one-quarter of an inch on the inside edge, and the paper filling is forced in under a pressure of 250 tons. Two iron disks, one on either side, and bolted together, keep the filling from coming out; but, as the tire bears on the paper and not on the disks, the wheel partakes of the elasticity of the former.

Biela's Comet.—Arago, to quiet all apprehensions of a collision of the earth with Biela's comet, made an accurate calculation of its orbit and periods, and so showed that such a catastrophe could not occur for thousands or even millions of years. But, as Prof. Daniel Kirkwood shows, in the *Journal of the Franklin Institute*, the break-up of that comet, which was observed in January, 1846, very materially alters the conditions of the problem, and now Prof. Kirkwood announces the latter end of November, 1892, as the time when, in all probability the earth and the comet will come in collision. The comet's period is about six years and eight months. After the break-up of January, 1846, it reappearance in

1852 was looked for with great interest, and it was then seen that its two fragments had not only remained apart, during the interval, but that the distance between them had increased. In 1859 no observation could be taken, and in 1866, though the circumstances were eminently favorable, no comet was seen. The same thing occurred again in September, 1872. But, when the earth's orbit, on November 29th, intersected that of the comet a few weeks later, after the passage of the latter, it was expected that we should have a view of the meteors forming its dispersed train. And such was the fact, as the records of astronomical observation all over the world show. "As the meteors of this cluster," concludes Prof. Kirkwood, "are doubtless the *débris* of Biela's comet, if we find the epoch at which the original body would have crossed the earth's orbit *near* the 29th of November, we may regard the collision of our planet with some of the large fragments — and hence a grand meteoric display—as highly probable at the same period. An easy calculation, which need not here be repeated, gives the last of November, 1892, as such an epoch."

Temperature in Disease.—In health the temperature of the human body is but slightly variable, rarely oscillating beyond one or two degrees on either side of 99° Fahr. In disease, however, the variations are greater, and in the disorders of young children wider even than in those of the adult. The temperature in grown persons has been observed to fall to 95° Fahr., and to rise as high as 107° Fahr., giving a range of 12°; and these are regarded as the extreme limits of variation in the ailments of adult age. In the sickness of children, according to M. Roger, the temperature sometimes falls to 74.3° Fahr., and may rise to 108.5° Fahr., which is equivalent to a range of 33.2°. In the typhoid fever of infants, the temperature in the majority of cases attains or passes 104° Fahr. Of the eruptive fevers, it rises highest in scarlatina, sometimes reaching 105.8° Fahr., next highest in small-pox, and in measles the least of all.

Among the diseases characterized by a fall of temperature below the normal standard, Roger observed in six cases that the mercury sank to 78.8°; in other cases the depression reached respectively 77°, 73.4°, 72.5°, and in one instance to 71.6°, or 27.4° below the temperature of health.

Hansen's Writing-Ball.—Under the title of "A New Writing-Machine," we alluded in a former number to the character of this invention, which during the past season has elicited a great deal of admiration both in the Copenhagen Exhibition and in London. Since first introduced to the public, it has been very materially improved, and now not only furnishes superior facilities for writing, but is admirably adapted to the purposes of copying as well. In the improved machine, the paper rests on a level surface, so that the operator is at all times able to see what he writes, and less time is lost in adjusting and removing the sheet. By interposing carbonized paper between the sheets, and making all move together, several copies may be written or printed off at a single operation. It will thus perform the duty of several copying-clerks, and has also been found admirably suited to the work of writing out telegraphic dispatches.

Mental Labor and Health.—The *Lancet* reverts to the question of mental labor and longevity, in order to correct some misapprehensions of its recent articles on that topic. "Intellectual activity," persists the *Lancet*, "is a preserver rather than a destroyer of nervous health: but this holds true only when the conditions of ordinary hygiene are not outrageously violated." If, coupled with the intellectual strain, we have harassing anxiety, sleeplessness will result, and this is fatal. But suppose there is no such anxiety, but merely ardor for work, then a man might easily transgress the plainest laws of health. The minimum of sleep required by the adult male in twenty-four hours, according to the *Lancet*, is six hours, and by the adult female, seven. As for night-work, the *Lancet* does not think it injurious *per se*. The light should be very white, powerful, and steady, otherwise there will be brain-irritation. The intellectual worker must obey implicitly the reversed scriptural law: "If a man will not eat, neither shall he work." He must take abundant nutriment, at proper times, together

with a "moderate amount of stimulants," says the *Lancet*. But any excess of alcohol or tobacco will produce insomnia: indeed, hundreds of cases where insomnia is charged to the account of "overwork" are best explained by excess in stimulation.

Dredging on the New-England Coast.—Prof. Verrill has a very interesting article in the January number of the *American Journal of Science* on the "Results of recent dredging expeditions on the coast of New England." In the summer of 1872 the headquarters of Prof. Baird, United States Fish Commissioner, were at Eastport, on the coast of Maine, and he invited the coöperation of Prof. Verrill and others in the work of making a thorough zoological survey of the waters of that region. Prof. Verrill had already devoted portions of six summers to the same work. The survey of 1872 not only carefully explored all the bays and estuaries, but also the deeper waters in their vicinity, more especially places known to be the haunts of valuable fishes; and the alcoholic collection of specimens obtained filled 2,000 bottles and jars, and several large cases.

Whenever animals were found to change in form or appearance on being preserved in alcohol, drawings were carefully made from life by Mr. J. H. Emerton, of Salem. The surveying party also studied and ascertained as far as possible the haunts and habits of such animals as form the natural food of fishes. The abundance and variety of living forms in the localities explored will be obvious from the statement that, besides *Foraminifera*, *Entomostraca*, and other minute creatures, the results of this and of previous dredgings, which have not been reported, add 350 species to the already known fauna of the region. Of these species some are undescribed, but the majority occur in the fauna of Northern Europe.

Marine plants were found growing at depths varying from shore-line to 80 fathoms: thus *Ptilota serrata* occurred at a depth of 75 fathoms. On St. George's Bank, in 430 fathoms water, 44 species of animals were obtained, not reckoning foraminifera. This is the deepest dredging yet done on our coasts north of Florida. The following were the temperatures here observed:

Air	66° Fahr.
Surface water	65° "
Bottom water	51° "

Prof. Verrill, however, thinks there may have been an error in the statement of the deep-sea temperature here, owing to defects in the instruments employed. He notes, at no great distance from St. George's Bank, the following temperatures for 50 fathoms water:

Surface water	62° Fahr.
Bottom water	45° "

And off Cape Sable a still greater coldness of the bottom was observed in 45 fathoms water, viz.:

Air	58° Fahr.
Surface water	56° "
Bottom water	35° "

In these cold waters the animal life found was more arctic in its character.

Between St. George's Bank and Nova Scotia the bottom was found to consist of fine soft, sandy mud. This, according to Prof. Verrill, may be owing to a depression of the area between the bank and the coast. This depression would withdraw the bottom out of the reach of the powerful currents which sweep over and outside the banks. Where these currents have full play, nothing but coarse sand and gravel is found even at a depth of 430 fathoms—nearly half a mile.

So strong are the currents, and so enormous their volume, in this part of the ocean, that to the east of St. George's Bank, where no bottom was found at 1,800 fathoms (rather more than two miles) depth, their mutual collision sufficed to produce a roar like breakers on a beach. The report is to be continued, and a complete list published of all the species of animals obtained.

Ostracism of a French Savant.—The new edition of Robin and Littré's great "Dictionary of Medicine" was lately presented to the French Academy of Sciences. Pathology is there regarded as a branch of biology, levying contributions on mathematics, chemistry, physics, and even social science and history. The Bishop of Orleans says that this dictionary lowers man to the level of the brutes; and the conservative justices of the peace of the sixth arrondissement of Paris take up the strain.

These wise judges declare M. Robin to be incapacitated, by his religious belief, from serving on a jury. They used to order such things better than this in France, but just at present there is an effervescence of emotional religionism in that country, and, as M. Robin is not in sympathy with it, he must be put down. The disqualified doctor is one of the foremost medico-legal authorities in Europe, and can well smile at the pettishness of the justices and their backers.

Causes of Horse-Influenza.—Prof. James Law contributes to the *Lens* a highly-important paper on "The Causes of Influenza in Horses." This is by far the ablest study on the subject which has yet been published, and we earnestly advise those of our readers who take an interest in the matter to procure the January number of the *Lens*, and peruse the discussion in full. We have space only for a brief summary. The author considers, one by one, the various causes assigned both by men of science and by empirics, for the outbreak and propagation of the disease. As regards the influence of *soil* and *elevation*, he finds that these cannot be proved factors in the problem, since the mountains of Vermont and New Hampshire were visited by the epizoötic no less than the flat and malarious sea-coast of New Jersey, Maryland, and Virginia. Again, it has been supposed that a low temperature is an active agent in aggravating the disorder; but Fulton County, Ga., showed a mortality threefold greater than that of Dodge County, Wis. And yet, after the outbreak of the disorder, in the last-named locality, there occurred a great and sudden fall of the thermometer. The author shows very clearly indeed that sudden changes of weather are not the cause of the outbreak, from the meteorological tables of Toronto, where the equine influenza first appeared. These tables show that during September, 1872 (the month of the outbreak), there was the average barometer and thermometer, and that the relative humidity of the atmosphere and the direction and velocity of the wind were normal.

Another cause often assigned is *acrid or fetid fogs*. But, in this respect, the month of September, 1872, showed nothing peculiar. With regard to the amount of *ozone* in the air, the author had no estimates; but he shows that, even were that gas proved to be in excess in September, it cannot be regarded as the cause of the rise or spread of the disease. His facts on this point are entirely conclusive.

He next considers what influence is to be attributed to the action of electrical disturbance. It is certain that September, 1872, was, at Toronto, marked by a high degree of electrical disturbance. But then was that the cause of the outbreak? That is by no means proved. If it *were* the cause, then we should have influenza at all periods of great electrical disturbance, which is not the case. The author is, however, disposed to allow that this disturbance may have "predisposed the system to the attack of a poison which existed previously."

There remains the theory of contagion, and this the author adopts. The contagion in this case is *specific*, confined to one species. Breaking out first in Toronto, it radiated in all directions, following the great routes of travel, and its progress is in nearly every instance traceable to the importation of animals from infected districts. But what is the nature of the *contagium* here—of the diseased or morbific matter transmitted from one animal to another? On this point there are two theories. One of these holds that the specific poison consists of fungi or the like. The other, which is that of our author, sees in the granules, existing abundantly in the diseased organs, the morbific agent. These multiply very rapidly, and are conveyed to a considerable distance through the atmosphere, in the clothing of human beings, etc.

The first-named theory, that which attributes the origin and propagation of influenza to vegetal organisms, is adopted by Mr. G. W. Morehouse, in the *American Naturalist*. He found in the matter from a diseased horse's nostrils, and also in the air, the spores of three different cryptogamous plants, of which he gives engravings. But he fails to tell us whether or no these same spores were in the air long before or after the disorder, as well as during its prevalence. Also whether these vegetal organisms are not equally to be found in the mucous discharges of sound horses. On this point, however, we are not left to conjecture,

for we have the authority of Prof. Law, corroborated by the observations of Dr. Woodward, for the statement that no "*specific* vegetal germs have been found in the air, blood, or nasal discharges, during the prevalence of the influenza."

Elevation and Subsidence of the Earth's Surface.—The *Philosophical Magazine* for December, 1872, contains an interesting paper by Captain F. W. Hutton, F. G. S., "On the Phenomena of Elevation and Subsidence of the Surface of the Earth," from which we condense the following: Assuming the increase of heat of the earth's interior to be 1° Fahr. to every 50 feet of descent, there occurs at a depth of about 23 miles an isogeothermal line or surface where cohesion of the rocks is overcome by heat, or rather would be so overcome at the ordinary atmospheric pressure. But the expansive force of the heat is balanced by the pressure of 23 miles of superincumbent rock, and thus a general equilibrium is maintained. The position of the earth's surface is due to three causes: 1. Its own weight; 2. Support of the interior mass; and, 3. Lateral thrust of the various portions against one another.

Whatever disturbs this adjustment must produce change of surface. If any elevation takes place in one section, there must follow subsidence in another. A great decrease of pressure is, doubtless, brought about by the radiation of heat into space, but this the author insists does not account for all the phenomena. There are two and only two agencies constantly at work, adequate to the production of this rise and fall of surface, and these are denudation and deposition, the latter being of greatest importance. The isogeothermal line will conform itself to undulations of the surface; so that, if a deposition of 100 feet of sand or rock occur, the line of heat will rise 100 feet, and the heat of the former line will correspondingly increase. Citing experiments of Colonel Totten and Mr. Adie illustrating the expansion of rocks by heat, the author says: "If the overlying mass be of loose particles, or sand, there could only be such elevation as would arise from increase of volume; but in case of solid rock, as limestone, there would be not only the increase of volume, but an arch-like elevation arising from lateral thrust. From this cause would arise ridges of elevation."

In illustration of this, he refers to the well-known elevation of the Wealden and Chalk of England. Here, with a thickness of the Cretaceous of 2,100 feet and of the Wealden of 1,300 feet, making in all 3,400 feet, we have a total rise of the arch of about 4,100 feet, the total breadth being about 100 miles. The elevation of the nummulitic limestone of the Eocene is also cited. This formation, 8,000 feet thick, is an ocean-deposit extending from Spain and Morocco to China and India, and has been elevated into enormous ridges, as the Atlas, Pyrenees, Apennines, and Himalayas. The author suggests that the cooling of mountain elevations as they rise above the snow-line may reduce the temperature of the surface, so that the rise of the isogeothermal is arrested, and further elevation ceases. On this point tables are given, showing the rise due to certain depths and areas of deposit.

Denudation, like cooling of surface, is supposed to induce subsidence in a given area by causing the line of heat to recede. But what could have disturbed the original equilibrium? "There can, I think, be but one answer to this question, viz., the origin of life on the globe. This life, by abstracting the carbonate of lime from solution in the sea, and depositing it on the bottom, first disturbed the equilibrium." The writer quotes freely from the statements of Babbage, Herschel, Croll, Hopkins, and others, to fortify points of this ingenious but perhaps in some respects fanciful hypothesis.

A Poison-Proof Bird.—A correspondent of *Science Gossip* tells of an attempt to capture a specimen of the scavenger-bird, or "adjutant," of India, in which he failed in a most unexpected way. On account of its valuable services in clearing the streets of decaying and putrid matter, the bird is held in high esteem by the natives, who take every precaution to protect it from harm. This prevented an open attack, and poison was the only alternative. The carcass of a partially-dissected bat was stuffed with enough arsenical paste and corrosive sublimate to kill twenty men, and the titbit

thrown to a flock of the birds near by. One of them swallowed the whole of it at a gulp, and our student in comparative anatomy thought his game secure. But, though closely watched for three hours, not the slightest sign of uneasiness was manifested, and at the end of this time the creature flew away with its fellows, apparently as well as the best of them. The accustomed haunts of the flock were afterward carefully searched, but no trace could be found of the dead body wanted; and it was concluded that, unlike other gormands, this one was not to be easily got at through his stomach.

Purpose of the Rattlesnake's Rattle.—In the *American Naturalist*, for February, Prof. Samuel Aughey gives the results of his observations upon the use made of their rattles by the rattlesnake. It is the vulgar opinion that the reptile sounds his rattle for the purpose of enticing birds, and some naturalists even are disposed to find here a mimicry of the sound made by the so-called locust, or cicada. Prof. Aughey does not undertake to explain all the purposes served by the rattle, but he fully agrees with Mr. F. W. Putnam in rejecting this mimetic theory. Does the rattle, then, serve any useful purpose? In reply to this question, the author tells us what he has himself observed. In July, 1869, he was in Wayne County, Nebraska, and, as he was one day investigating the natural history of that district, he heard the familiar rattle of the snake. The sound was repeated at intervals, and proceeded from a rattlesnake that was calling its mate, which soon came in answer to the summons. Prof. Aughey had a similar experience the following year, and from these facts he is disposed to think that the purpose served by the rattle is to call the sexes together.

Another purpose may be to paralyze its victims with fright, and to inspire its natural enemies with terror. As an illustration of the use of the rattle for the former purpose, the author says that, as he followed through the woods of Dakota County, Nebraska, a Baltimore oriole, he heard a rattle, and at once saw the bird as it were paralyzed with fear, and ready to fall a prey to the serpent. The writer shot the rattlesnake. He adds that he once witnessed an attack of seven hogs on a rattlesnake. Soon after the battle opened, the snake rattled, and three others came to his aid. But the hogs were victorious in a few minutes.

OBITUARY.

Professor Matthew Fontaine Maury, whose scientific labors in the Hydrographical Office, Washington, earned for him eminent rank among *savants*, and were of inestimable benefit to the commerce of the world, died at Lexington, Va., February 1st, aged 67 years. At the time of his death he was Professor of Physics in the Virginia Military Institute. He was author of a "Treatise on Navigation," of a "Physical Geography of the Seas," of "Letters on the Amazon and Atlantic Slopes of South America," and other works.

The eminent French naturalist Felix Archimède Pouchet died December 6, 1872, at Rouen, in the 73d year of his age. He is best known to fame by his researches into the question of spontaneous generation, on which he held the affirmative side. He was a very voluminous writer, his principal works being on "Spontaneous Ovulation," and "The Organs of Digestion, Circulation, and Respiration." He was educated for a physician, and was for a long time professor in the Rouen School of Medicine.

The Rev. Adam Sedgwick, LL. D., F. R. S., F. G. S., Professor of Geology in the University of Cambridge, England, died January 27th, aged about 90 years. He long stood in the foremost rank of men of science in England, and was, both alone and with the assistance of Sir R. Murchison, the author of several works on geology. His first acknowledged publication appeared in 1822, and treated of the physical structure of the Devonshire and Cornish formations. In 1851 he was awarded the Wollaston Palladium Medal for researches into the geological structure of the British Isles, the Alps, and the Rhenish provinces. Two years before his death he resigned his professorship at Cambridge, but to the last took a warm interest in the progress of science.

NOTES.

THE Mont Cenis Tunnel labors under a very serious defect—that of insufficient ventilation. Under ordinary circumstances the difference of temperature at the opposite sides of the Alps is such as to keep up a steady current of air through the tunnel. But it may happen that the temperature at both ends shall be the same, and then the air within will be stationary. A freight-train recently came to a stand-still, all hands on board having become half asphyxiated by foul air. Another train came to the rescue in time to save their lives. The tunnel, therefore, cannot be relied upon at all times to ventilate itself, and some artificial mode of ventilation must be applied without delay.

A COMPARISON made between smokers and non-smokers belonging to the Polytechnic School of Paris shows that the non-smokers take the highest rank in every grade. Further, it is found that the smokers lost grade constantly. In 1861 the Minister of Public Instruction accordingly issued a circular forbidding the use of tobacco by pupils in public schools.

THE *Food-Journal* quotes from the *Swiss Times* the statement that the sale of horse-meat has been authorized by the authorities in Geneva, the price per pound for the choice morsel being regulated by law.

A SEARCHER of ancient records has exhumed the following weather statistics for Germany: In 1241 the trees bloomed in March, and in May cherries were ripe. In 1289 there was no winter, and young girls wore wreaths of violets at Christmas. In December, 1538, the gardens were green, and in full bloom the following month. The years 1572, 1588, 1607, 1609, and 1617, were similarly abnormal. There was neither snow nor frost in 1659. The trees bloomed in February, 1722. The year 1807 was extremely mild, as also 1834 and 1846.

ONE of the newest uses of paper is to employ it as *skins* for sausages. This is of course a German notion, and Würtemburg is its birthplace. Unlike the *skins* commonly used, the paper envelop is not subject to fermentation, and is cleanliness itself.

IN spite of the heavy fines imposed upon milk adulterations in the cities of Ireland and England, the fraudulent practice still goes on; the fines being paid by societies organized in the interest of the fraud. To meet this difficulty, milk-consumers are urging the authorities to add, to the imposition of fines, the punishment of imprisonment, as the only effective deterrent that can be brought against this class of swindlers.

A REPORT on the average life of academicians, addressed to the French Academy of Science, by M. Potiquet, shows that the mean age of members of the French Institute, from its foundation in 1795 down to November, 1869, is 51 years and 10 months at the time of their election, and 71 years and 5 months at the time of their decease. The latter figure shows an uncommonly high average of life, and will doubtless cause some surprise; and yet, as the author has bestowed great pains on his tables, and taken every precaution to avoid error, his results may be confidently accepted as entirely trustworthy.

A WRITER in the *Medical Record* commends the use of borax, as a remedy for the hoarseness or loss of voice common among public speakers and singers. A few minutes before any continuous exercise of the vocal organs, a small lump, three or four grains, of borax is to be slowly dissolved in the mouth and gradually swallowed. The solution acts upon the orifice of the glottis and the vocal cords precisely as "wetting" acts upon the notes of the flute. It is also stated that five grains of nitre taken in a glass of water, the body being wrapped in extra clothing, will excite a gentle perspiration for an entire night; and this treatment will break up a cold if employed at its first onset.—*Detroit Review of Medicine.*

A CAREFUL estimate gives the population of the globe as follows: Europe, 301,600,000; Asia, 794,000,000; Australia and Polynesia, 4,365,000; Africa, 192,520,000; America, 84,524,000; total, 1,377,000,000. London has 3,251,000, ranking first among cities in point of population. Next comes Su-choo, China, with 2,000,000. Five cities in China have an aggregate population of 6,884,000 inhabitants.

A MAN in Brussels, while under the influence of intoxicating liquor, fell into the Canal Charleroi. After some trouble and considerable loss of time his body was recovered and taken in charge by Dr. Joux, police-surgeon. After trying all the usual remedies for three hours, Dr. Joux applied iron, at a white heat, to the upper part of the body, near the vital organs. In half an hour the man awoke to life.

To obviate the slipperiness of asphalt pavements, it is proposed to mould the asphalt into blocks about the size of the ordinary granite blocks, and in the centre of each to fix a piece of stone or of wood.

OWING to the prevailing floods, salmon were to be found throughout the whole winter in all the rivers of Ireland. In the streets of Bandon, seven salmon were killed in one day, some of them in the very houses.

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